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Problems before British Manufacturers.

DURING the past twelve months a great cry has gone up throughout the country, calling on our manufacturers to reform their business methods, and to cast out from their works the antiquated plant and machinery which has been one of the chief causes of our failure to keep pace with the industrial advance of other nations, and to set in their place such new and improved mechanical appliances as those which have enabled our competitors to inflict such defeats upon us in home and international trade. Considerably more zeal than discretion has been conspicuous in the jeremiads on the decline of British commercial ascendency which have lately formed such a feature in the general press, but that a certain basis of truth has underlain the strictures on British industrial lethargy is unquestionable.

It would be impossible to establish manufacturing centres in our midst, founded on alien methods and alien machinery, if our own were up to the mark; and although the instances which may be cited of these certainly relate exclusively to one branch of engineering science, which, owing to causes quite apparent, we have admittedly suffered to fall into neglect, there is an uneasy feeling that in many other sections of manufacturing industry we have fallen behind the practice which has developed in countries which we must be prepared to face as permanent, determined, and most formidable antagonists in the markets of the world.

Apart from certain isolated facts that go to strengthen such a presumption, a brief comparison of British and American policy in the design, construction, and use of machines affords *à priori* evidence at least that the presumption is likely to be correct.

We find that British machines, in their broad expression, are designed and built, apart from their main end, chiefly for endurance. That is to say, the machine, whether loom or steam-engine, is designed for a life whose finality is determined simply by the solidity of its construction and excellence of workmanship. In these essentials Britain still holds the field. The policy of the "scrap-heap" has been unknown to us, whereas the American machine, for instance, is made on the assumption that within a certain period it will become superseded by some improved contrivance which will do the same work either in a better way or with greater productiveness or smaller cost. And the moment such appears it is the policy of the manufacturer, largely acted on, to cast it out, irrespective of any regard to wear, and to set the new invention in its place.

The value of this principle has lately been the subject of considerable disputation in relation to railway locomotives; but leaving for the present any discussion of a theory which, if acted on, would open a new chapter of manufacturing economics in this country, we may address ourselves to a brief survey of the conditions as they

stand in connection with the re-equipment of English manufactories with that modern machinery which is declared, and justly so, to be such a necessity for the national welfare.

There are four factors concerned in this very grave and important question. There is the manufacturing engineer, or, as he may be termed in this connection, the machinist; there is the user of the machines, or, as we may call him, the manufacturer; there is the question of Capital, and there are the Trades Unions.

The Necessity of Re-Equipment.

Now, it is a matter of common admission that the British engineer in designing and constructive ability stands pre-eminent before the whole world. He is equal, and more than equal, to any call made upon him. He only awaits that call.

But is it as clear that he is dependent on that call for the full employment of his energies; that unless there is a demand for his invention and skill these qualities will not be brought into their full employment? So long as the manufacturer remains content with his existing plant and machinery, so long the market for new, improved appliances will remain restricted, and the development of constructive engineering slow and semi-stultified. It is the readiness of the American manufacturer to adopt, no matter almost at what cost, the latest improvement in mechanical science that imparts confidence and inducement to the machinist to devise and undertake succeeding improvements in his handicraft, for he knows that whatever improvement he may be successful in producing will find a ready and immediate market. The American, therefore, constructs for a period of temporary utility; whilst the Englishman too often appears, like the ancient Romans, to have in view the prospect of succeeding ages.

None the less it is apparent to even superficial observers that a new spirit is growing in the country, and that many manufacturers are taking stock of their mechanical resources on a basis of comparison with their competitors across the Atlantic. Instance after instance, some of them notable, have come to light where reforms of a radical, even of a destructive, nature have been made. We hear of whole areas of buildings being dismantled, and even pulled down, to make way for the airy and commodious structures, filled with the latest types of improved machinery, now characteristic of the best type of modern manufactory. One of the strongest incentives to any given line of conduct is successful example, and we cannot doubt that these examples would find many willing imitators among those who are still perforce compelled to remain content with machinery, buildings, and plant they know to be hopelessly out of date, and who have the will to remodel their factories, if they only possessed the power.

The Question of Finance.

What is that power? Simply the power of capital. Without capital, ample and even lavish, all attempts at such improvement on a sensible scale are futile, and only leave the last state of the reformer worse than the first. This is the great deterrent to manufacturing reform in this country, and it is a question which is certainly worthy of far greater attention than it has received up to the present time.

The Government of no other manufacturing nation displays such indifference to the promotion of its commerce and manufactures as our own. Such indifference may doubtless be due to that precedent which can be traced back to the period when British commerce, having practically no competitors, was supreme. However that may be, as we usually find the qualities of a ruling factor transmitted to its environment, we see this state of indifference reflected to some degree in those circles which under other auspices are more keenly and vitally interested in national industry.

Although English banks and other financial institutions in this country stand on the most niggardly terms with regard to any manufacturing enterprise, we all

know that practically the whole fabric of recent German manufacturing industry has been created, raised, and established by the "Industrial" Banks of that country. Opinions may vary as to the wholesomeness of the operations rendered possible by financial support secured in this way, but financial support, even if misdirected, is perhaps better than no financial support at all; and it is the fact that in contrast with Germany, there is probably not a single bank in this country to which a manufacturer could address himself with any confidence for help in the re-equipment of his works, however adequate, from one point of view, his security might be.

But unless capital in some form is forthcoming, how are the great mass of our older manufactories, most of them already hampered in the bonds of limited liability, to effect those reforms which no one can deny are imperatively necessary in the general interests of the country?

It is hardly reasonable to suppose that "Industrial" Banks are a species of growth indigenous to Germany, which would perish under any attempt at cultivation on these shores. On the contrary, we should presume that, founded on the same basis, managed on the same lines, and doing business of the same kind, an "Industrial" Bank here might be competent to benefit its customers, with the same benefit to itself, as elsewhere. It is not, however, for us to formulate, but to suggest. We believe a more liberal and enterprising system of industrial banking in the country is at this period a crying want, mainly, if not altogether, for the purpose set forth. It is earnestly to be hoped that sooner or later some attempt will be made to meet it.

The last question remains—that of the effect which such new methods and machinery as those referred to might be expected to produce in relation to the labour question.

Trades Unions.

A recent visitor to the United States, who narrated his experiences during a course of investigation among the great manufacturing-centres of that country, has stated that nothing in his experiences impressed him more than the deserted aspect of vast halls of machinery, in which, however, work was proceeding at its highest point of productivity.

This, he explained, was due to the employment of automatic machinery of the highest type, requiring no continuous attention, but merely casual supervision at considerable intervals. Wages, he stated, formed an inconsiderable fraction of the prime cost of a manufactured article, compared with similar work in England. This brings us to a consideration of the ultimate attitude of the trades unions.

Recently the unions have afforded a fair instance of the inference raised by the quotation, *Qui s'excuse, s'accuse.* They have, through the mouths of their spokesmen, been loud in their protestations against the statement that there is a disposition among them to take work easily in the common interest, so as to afford employment, as far as possible, for all. We might be disposed to place more faith in these disavowals but for a consideration of the fundamental and unalterable elements of human nature. Where there can be no inducement to work too fast, owing to the existence of a uniform wage for super-efficient and ordinary-efficient alike, the inevitable tendency will be to work too slow—*i.e.* it is the standard of the lowest efficiency which governs the conditions, instead of being—what it might be—the highest.

Under the present conditions of employment the trades-unionist's interests are, and must be, inimical to those of his employer. It must be the aim of every unionist of ordinary ability to do as little as he decently can; for in any case he does not receive any further reward for extra exertion, and otherwise he would be rendering himself obnoxious to those receiving the same pay, but who are lazier or not so competent as himself.

It is chiefly in his attitude toward automatic machinery that the trades-unionist is of present interest. That the unions have done all in their power to destroy the utility of this class of machinery is absolutely incontrovertible. It is true that, excepting in some isolated instances, they have made no forcible exertion to prevent its introduction. This may be

acknowledged; but the fact is notorious that no means have been neglected to pervert, injure, and destroy its economical working. By insisting that each machine should be invested with its own separate attendant, they tried to minimise its power of economy. By running at half-speeds, and, in the case of lathes, taking light and superficial "cuts," they sought to effect the same purpose. In every way they have endeavoured to hamper, impede, and stultify the operation of an appliance which is now absolutely indispensable in its highest powers, if English manufacturing industry is to be allowed to retain its position. The dislike to automatic machinery still continues and appears to be inveterate. Doubtless there is great excuse to be made for a mind that is unable to grasp any but the most immediate and material fact; but those among the trades unionists—and there are many—who do not hesitate to reprobate in the strongest language the machinery-breakers of the early century should be reminded that their own methods, if more insidious, are hardly less injurious, and that in any case they are intended to bring about the same end as that their ignorant predecessors had in view sixty years ago.

The Future.

The future of employer and employed in this country is dim and troubled to the view. The general intelligence, honesty, and law-abiding qualities of those who comprise the body of the great trades unions we should be the last to depreciate. Their failing, in our judgment, is one common to all men and under all circumstances—the confining of themselves to but one point of view. For the ethical standard, which has so often been propounded on their behalf, we have nothing but the sincerest admiration—in the abstract. But unfortunately in this world it is hard to realise the ideal, and whilst the British workman concentrates his attention on the effort to "raise the standard" of his living he may find unexpectedly that this living has departed from him to someone across the seas whose ideas of the realities of life have rested on a more practical basis.

The Royal Commission on Coal and the Coal Duty.

THE appointment of a Royal Commission to inquire into the coal resources of the country, and into other aspects of the coal question, has been received with general approval. There can be no doubt of the necessity of such an inquiry, if it be only to revise the estimates of the Commission of 1871, which time has falsified. There is, however, room for criticism in the composition of the Commission, on which neither the commercial nor the industrial element is sufficiently represented. And it is a lamentable defect that no special instruction is given to the Commission to inquire into the incidence of the export duty on coal, and to report on its actual effects so far, and on its probable effects if continued. As the close of the fiscal year approaches the subject of this tax is being more and more warmly discussed.

The Inexpediency of the Tax.

The disturbance which it has caused in the coal and shipping industries is not, of course, in itself an argument against the economic justice of the tax, but it is certainly *primâ facie* evidence against the expediency of it. When the need exists for finding new sources of revenue, any new tax imposed should be of such a character as to be exigible and permanently maintainable without injury to trade. Can that be said of the coal tax?

A dispassionate inquiry into the whole incidence of the tax leads us to the conclusion that it will not ultimately affect the profits of coalowners. It will become a prime cost charge, to be estimated in the adjustment of wages and the arranging of price. In so far as it is treated as what in Scotland is called an "oncost" charge, it will form an item in price, and therefore a tax on the home consumer; but a general opinion in the trade is that the miners are not far wrong in thinking that practically the whole of the duty will ultimately come off their wages. This will be the more readily effected, of course, if the duty serves to restrain the foreign demand and to restrict exports. As to this, time will

show, though the experience of the first year will not in itself be conclusive. The incidence of contracts, and the dislocation always caused by the introduction of any new method or system into the avenues of commerce, prevents the normal effects from being at present distinguishable. If, however, the effect is to reduce or prevent the expansion of exports, then it will also be to reduce or restrict the output, with a consequent smaller employment of men and a larger percentage of administrative charges on the quantity mined. If the duty has no effect on the volume of exports then it will fail in what is its chief recommendation to many—the conservation of the national resources.

Its Effect.

The probability is that coalowners in future dealings will make special prices for export—as is done in several trades already—and will recoup themselves for concessions to exporters by maintaining prices and lowering wages at home. The more it is examined the more it will be seen that the duty is a tax neither on coal, nor on the producers of coal, nor on the exporters of coal (except in the first instance, and subject to adjustment), nor on the foreign consumers of coal, but on the export trade in coal. Really to tax coal the Chancellor of the Exchequer must go to the pit mouth, for only there could an impost be exacted that would be equitably distributed over all classes concerned in the production and consumption of the mineral. Whether we should tax coal solely for the purpose of preventing the depletion of our national supplies is a wholly different question.

What the Harbouring of our Coal Resources means.

If the country is determined to preserve its coal for posterity, it will have to do so by sacrificing a large portion of its maritime trade, and by increasing the cost of living in these islands. A proposal for such a sacrifice is not yet within the range of practical politics—and before it does come within range science may discover that the conservation of coal is unnecessary—and so we do not discuss it just now. The Budget duty was imposed solely and purely for revenue, and it will produce very much short of what the Chancellor expects from it this year. Unfortunately this may tempt him to propose to increase it, than which nothing could be more unwise.

Upon whom has the Burden so far fallen?

Up till now, solely upon the shipowner. The drop in coal freights since the Budget is more than the amount of the duty; and upon the reduced freights merchants offered and received orders for cargoes for both North Europe and the Mediterranean at just about the same c.i.f. prices as they were quoting before the Budget. The only one, therefore, who has really felt the burden until now is the shipowner. We do not argue that the tax will rest permanently upon the shipowner and upon him alone. He has borne the brunt of it so far, but it will ultimately come off the export price and be put, as has been said, on to the miner and home consumer. There is no room for doubt about that among people who can regard the matter with unprejudiced eyes.

How badly the Chancellor was coached

was evident in his replies to the numerous questions with which he was bombarded in the House. For instance, Mr. D. A. Thomas asked him if he had formed any estimate of the quantity of coal consumed in the production of pig-iron, and of what proportion of it is exported abroad. And Sir Michael replied, "I have no knowledge as to the quantity of coal used in the production of pig-iron in this country." Yet he could have got the information in half an hour. We can supply him. In 1900 there were 18,742,022 tons of coal consumed in the production of 8,959,691 tons of pig-iron, and there were 1,427,525 tons of pig-iron exported. The figures for 1901 are not yet available, but there is no mystery about it. It may be taken that every ton of pig-iron represents at least 2 tons of coal. In 1901 we exported 839,223 tons of pig-iron, equal, therefore, to 1,678,446 tons of coal at least. But, besides that, we exported some 2,000,000 tons of finished iron and steel, in the production of which from 6 to 8 tons of coal would be consumed for every ton of finished material. Take the average at 7 tons, and there you have 14,000,000 tons

of coal exported in the form of iron and steel.

It should be one of the first objects of the Royal Commission to seek data on which to estimate the industrial effects of the coal duty. Meanwhile we do not agree with those in the iron and steel trade in this country who think that the duty will tend to cheapen fuel for them. Coal was on the down-grade before the Budget, for the plain and simple reason that the industrial consumption of it was declining all over the world, while the output was being maintained, if not increased. And coal would have been a good deal lower than it was when the Budget was introduced but for the high range of colliers' wages. Until these wages are restored to normal relations with price, the iron and steel industries have little chance of reviving. The coal duty certainly will not help them.

Electrical Response in Inorganic and Living Matter.

A FIELD of inquiry of most extraordinary interest has been opened up by Dr. J. Chunder Bose in a course of the researches of which those into the "coherer" used in etheric telegraphy formed the starting-point. The details of these are to be found in a series of papers recently read before the Royal Society.

In inorganic substances the existence of molecular strain is shown by changes in electric conductivity.

Experiments on inorganic substances, under the action of electric radiation, are best made with the material in a state of powder, as a larger surface is then exposed to the radiation, and the molecules are subject to less constraint. There is also another reason of an extremely interesting character, to which we shall refer presently.

Professor Lodge's theory of the "coherer" action of a powder was that the particles became welded together by the production of minute induction sparks, but if this were the case the effect should be invariably to increase the conductivity.

Now, Dr. Bose has shown that the conductivity is increased in some cases and decreased in others, with a tendency to recovery, depending on the nature of the material and other circumstances, such as temperature and the strength of the radiation.

When recovery is very rapid, as in the case of potassium, there is no permanent distorsion.

Recovery from a state of strain would naturally be assisted by molecular agitation, which explains the effect produced by tapping, and a slight increase of temperature usually acts in a similar way. Allotropic transformations, such as that of yellow phosphorus into the red variety, and soluble sulphur into the insoluble form by the action of luminous radiation, are examples of permanent molecular distorsion. A very curious and noteworthy fact is, that when a feeble radiation causes an increase in the conductivity a stronger one will frequently, if not always, cause a diminution, and *vice versâ*. This is the additional reason in favour of experimenting on substances in the state of powder, to which reference was made above. If the substance were used in the solid state, with its surface exposed to a strong radiation, the radiation would be enfeebled as the depth below the surface increased, so that only the difference of the two opposite effects would be observed.

A very noteworthy point is the continuity in the nature of the effects of electric vibrations, varying from the most rapid luminous vibrations down to a single electric shock.

The author has obtained a number of response curves by taking the galvanometer deflections as ordinates, and the times of exposure (or recovery) as abscissæ.

These curves possess an extraordinary interest, on account of their exact correspondence in every detail with those so well known to physiologists as expressing the phenomena accompanying the subjection of muscle to mechanical strain.

One of the most suitable substances for the observations from which these curves

are obtained, was found to be slightly warmed magnetic oxide of iron, as the effects on this substance take place slowly enough to be recorded without difficulty, while the recovery under the right temperature conditions is rapid, and there are no secondary chemical actions. There is always a latent period between the stimulus and the response, which latter rises to a maximum after the cessation of the stimulus, followed by a rapid recovery. With some substances a tendency to after oscillation can be observed, but this is never so noticeable as in the muscular strain curves.

When a second stimulus is applied, following one of moderate amount, there is a summation of the effects, but if the second stimulus follows one strong enough to produce the maximum effect, there is no further result. When stimuli follow with slow intermission a broken curve is obtained exactly similar to the corresponding muscular ones, while with rapid intermissions the curve becomes continuous, as in the tetanic state or *rigor* of a muscle.

This close resemblance between the effects of electric stimulus on inorganic substances and living tissues is even more remarkable in the results of the author's observations on the effect of radiation on the sensitive surface of the retina.

It is well-known that visual sensation can be produced by an electric stimulus applied to the optic nerve. The visual current effects may be due either to molecular strains giving rise to e.m.f.'s or merely causing changes of conductivity in the presence of an already existing e.m.f.

Dr. Bose considers that the feeble visual sensation observed in the dark, and known as the *intrinsic light* of the retina, points to the existence therein of an independent e.m.f. In either case the cause would be molecular strain due to radiation.

Dr. Bose's work has opened up an extensive field of research, both to the physicist and the physiologist, and would appear to have brought us to the threshold of generalisations of the most far-reaching character.

The Practical Column.

EVERY engineer who has occasion to design or to dimension many columns will recognise the importance of differentiating between the nature of the load imposed. Amongst the formulas in general use there are none that provide for calculating the effects of eccentricity of loading, and as a matter of fact very few writers upon the design of such members realise or appreciate the importance of this feature. In buildings most of the columns are comparatively short, and the existence of eccentric loading is a feature that ought never to be overlooked. The subject is one which has received most painstaking treatment at the hands of Mr. J. M. Moncrieff, M.Inst.C.E., in a lengthy paper read last year before the American Society of Civil Engineers. The object of the writer was to develop a practical and simple theory of column strength under central or under eccentric loads, on the following lines. The theory to be based on correct principles, and the formula to be of correct form without introducing refinements having little practical influence on the results. The theory and formulas to cover all the conditions met with in engineering practice, the theory to show agreement with the results of practical experiments and the formulas to be applicable to different materials, by simply introducing the values of the ordinary physical constants of strength and stiffness. In order to indicate the nature of the reasoning followed, the following points may be cited:—(1) That a perfectly centred column of perfect materials and straightness is an ideal conception seldom or never realised in practice, and (2) that the various disturbing influences preventing the realisation are practically all capable, as regards ultimate effect, of being represented by an equivalent eccentricity of loading. Working upon these lines, the author proceeds to demonstrate his theory, and to compare the resulting formulas with the results of nearly 2,000

tests of columns by various experimentalists. It would manifestly be impossible to discuss so large a question within the limits of this page, but we may express the opinion that Mr. Moncrieff has evolved a series of formulas which ought to be of the greatest possible value to professional men, and they possess the merit of being sufficiently simple to be understood by those who are not expert mathematicians.

British Export and Import Trades.

THE statistics of our export and import trade are published with commendable promptitude, and the officials charged with the publication of these factors deserve credit for their energy and zeal in laying before the British public the data which, in their view, are to form a reliable forecast of the commercial outlook. Unfortunately, however, a patriotic and well-informed contemporary has proved beyond a shadow of doubt that the method adopted in the Board of Trade returns renders the latter quite misleading. He points out that the Board of Trade returns relating to our over-sea trade in October, if published in such a manner that they run parallel with another column containing the figures of 1899, become of much more value as a basis of comparison; and that a comparison of three years, rather than two, is of exceptional value at the present time because of the high level of prices which obtained last year. The addition of one extra column in the summary tables of the *Reports* would cause, says the writer, little extra trouble to the officials, while it would render unnecessary much inconvenient reference to the returns of last year to those who wish to see the trend of our over-sea trade.

On November 23rd, *Commercial Intelligence*, which is the contemporary referred to, goes one step further in laying down a programme for an admirable reform in the publication of the Board of Trade statistics, based on the very favourable reception that its suggestions received on the part of other competent press organs and of persons who are considered qualified judges of industrial matters. Practically, British Chambers of Commerce have passed resolutions strongly endorsing the views held by *Commercial Intelligence*, and we ourselves do not hesitate to say that if in any way we can aid this movement in the right direction we shall always be really glad to do so.

As regards our views on the value of statistics, we have mentioned them so frequently that our readers will spare us the task of repeating them. We may say, however, that if taken from unreliable sources, or grouped in a way that in nine cases out of ten the reader will jump at a conclusion which, though fitting the hobby of the statistical writer, is totally opposed to truth, the statistical records might just as well be at once consigned to the waste basket.

The Fire on the Liverpool Overhead Railway.

WHENEVER an accident of any kind occurs on an electrical system it is certain to give rise to panic-stricken articles in the daily Press.

These articles are written from the standpoint of the man in the street; for, with very few exceptions, technical knowledge is the last thing that the editor of a daily paper would think of requiring from the members of his staff to whom is allotted the duty of dealing with technical matters in the columns of his journal. Now, to the man in the street, electricity is little more than another name for mystery. The reason of this is not far to seek. If he asks an electrician or an electrical engineer what electricity is, the latter will reply that he does not know.

The conclusion drawn by the man in the street is that so little is known about

electricity that it is a dangerous agent to employ, and one which may, at any moment, break free from control and act in an unforeseen and possibly terrifying manner. In this conclusion he is quite wrong. There is no branch of engineering in which the plans can be laid down beforehand with such exactness, and with such certainty of producing the desired results, as in electrical engineering. The man in the street is all unaware that if he were to ask a physicist or an engineer what matter is, the reply would be just as unsatisfactory.

The conclusion drawn by the totally uninstructed in electrical matters from the recent fire on the Liverpool Overhead Railway is that, in a tunnel at any rate, electricity is a more dangerous means of traction than steam. This, again, is incorrect. A boiler explosion in such a tunnel would, in all probability, have produced far more disastrous results than those caused by the breakdown of a motor armature, serious as these were. The man with a little knowledge has drawn another erroneous conclusion, viz. that the multiple-unit system is a dangerous one from the point of view of fire risks. If this were so, it would be equally applicable to the ordinary electric tramcar.

The lessons to be learned from the Liverpool disaster are obvious, so obvious indeed that, in calling attention to them, we might well be accused of giving vent to mere platitudes, were it not that the occurrence of such easily preventible accidents as this one shows that, obvious as they are, they have not been laid to heart. The first is that electrical machinery should be regularly inspected, instead of the necessity of repairs being left to be inferred from breakdowns. The horror of the results which would ensue if steam locomotives were run till a breakdown occurred, instead of being subjected to the most rigorous and systematic examination, are too fearful for contemplation. The second lesson is that motors placed in cars built mainly of wood should be encased in such a manner as to prevent any possibility of a burn-out in an armature setting fire to the car, which is a perfectly simple matter.

Motor-Car Prospects.

THE advice, "Never prophesy unless you know," is, no doubt, sound enough. There are, however, signs of the times which, if carefully watched, are fairly safe indications of what is likely to occur within the near future, since the future has its roots in the present, just as the present has sprung from the past. Among such premonitory signs, there are the many indications that the motor-car industry will be among the leading industries within the next decennium; and though perhaps the impending "boom" will be followed by a reaction ere a solid basis for legitimate enterprise is established, it is not likely that the demand for self-propelled vehicles will be ephemeral in its character, as there are so many uses for them; and their number is certain to increase rapidly within the near future.

The fact that in this country the number of vehicles in which animal traction is superseded by mechanical propulsion is as yet comparatively limited, is not entirely due to impediments placed in the way of auto-mobile owners by injudicious legislation and prejudices on the part of local authorities. It is accounted for also, to some extent, by the circumstance that at the present moment nearly all the makers of motor carriages are engaged in devising improvements upon existing types, and endeavouring to remedy the defects that the experience of the last few years has brought to light. Among intending buyers, of course, there are many who prefer to wait a little longer, some of them in the hope that ere long a type will make its appearance of such perfect construction as to render it unlikely that it will be superseded before many years by another possessing essential advantages over it. They are aware that this is a transition period, and hesitate to expend money for a high-priced article that may at any moment become obsolete, and therefore useless to them. Others, again, await the advent of a standard motor-wagon for an equally good though diametrically opposite reason. Their hope is to buy one of these obsolete types, the leading type of yesterday, for a mere song. Both

of these cautious groups of purchasers are basing their anticipations, it cannot be denied, upon a correct grasp of the existing condition of affairs in the motor-car industry, for they realise that the work being done at the various works is very experimental in character.

To support this assertion on our part it will suffice to glance at the records of the Patent Office at Washington, which is a very fair thermometer of the international rise and fall in industrial enterprise as regards the enthusiasm for improvements. The automobile section at the American Patent Office is at this moment by far the busiest of all sections. Applications for patents comprising improvements in motor cars in general, or in any special part of such cars, have of late become so numerous that five special examiners had to be appointed for this class of applications, and four separate divisions had to be organised, each of which deals exclusively with a certain class of inventions concerned with motor-car problems. Thus one division is occupied with electric auto-motors merely, a second with steam-motors, a third with the various kinds of vehicles propelled by gas (including acetylene motors), while a fourth is in charge of patents referring to compressed-air motors. Under ordinary circumstances, one special examiner is able to deal with all the applications relating to one class of work, and an increase in the number of special examiners is of very rare occurrence. The only occasion when a rush even greater than that for auto-mobile patents at present took place in one of the sections into which the work at the American Patent Office is divided, was at the time when the great bicyling mania, some years ago, was at its climax.

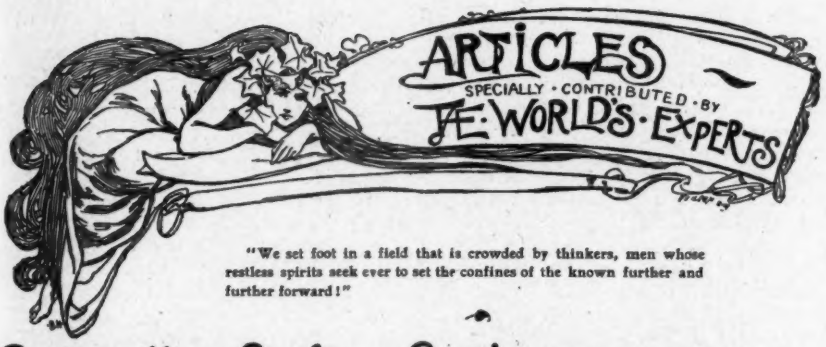
At that time ten special examiners had to be detailed for the work of dealing with bicycle patents to assist the sectional chief to whose section such patents belonged. After the rush was over these additional examiners were gradually withdrawn, and at present two only remain. Notwithstanding the unavoidable reaction, however, the abnormal activity among inventors that anteceded it was not entirely without profit, for its result was the production of a number of types far ahead in construction and efficiency of the older kinds, and, by analogy, it may be anticipated that, even though the present abnormal competition among inventors anxious to devise perfections in the construction of motor vehicles is not without its drawbacks, it will lead to the designing of some standard types, which, if they do not reach the theoretical ideals in their special lines, are, at all events, an approximation to them, and sufficiently excellent to perform for many years the work for which they are intended, without awakening an urgent desire for improved patterns.

American Workshop Methods in Steel Construction.

Mr. H. B. MOLESWORTH, M.Inst.C.E., in a paper on the above subject read before a recent meeting of the Institution of which he is a member, summed up the causes of cheap working in America as follows :—

1. The workmen, though more highly paid than in England, turned out a much larger quantity of work.
2. The arrangement of the works was more carefully thought out, and labour-saving appliances were more used.
3. There was more method, and probably more scientific knowledge, in the drawing-office.
4. The works were run night and day.
5. The templating was reduced to a minimum by care in the drawing-office and by the use of automatic machinery and stops and guides.
6. Obsolete machinery was turned out of the works as soon as it was superseded by anything better.
7. All tools were kept in a state of perfect efficiency.
8. Railway freights were lower than in England.

Perhaps item No. 5 is as important as any, as there is no doubt the saving which is possible by systematic methods in the drawing-office, and the use of stops and guides and multiple punches, so as to reduce the templating, is very great. Small portions of the work should be made interchangeable, and turned out without having to mark each piece.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Evaporative Surface Condensers.

By HARRY G. V. OLDHAM, A.M.I.Mech.E.

THE problem of steam condensing is always an interesting one, and one that merits the close attention of all who are responsible for the economical running of large power and lighting stations and manufacturers using large quantities of steam.

It is only recently however that steam users have been alive to the large saving that may be effected by the use of efficiently arranged condensing plants; a saving from 20 to 30 and even to 40 per cent. in coal consumption is not excessive in such cases.

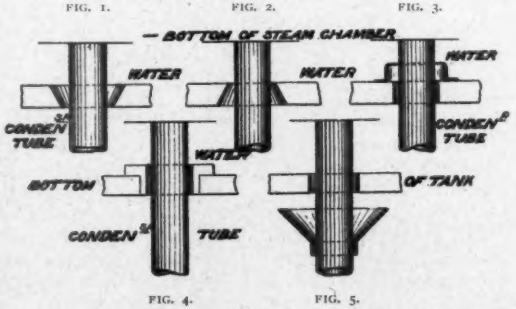
There are various types of condensers that more or less effect this purpose, and it is often a debated question, which is the best type to adopt.

Certain types are inadmissible, by reason of the large quantity of cooling water consumed. In some plants working with cooling towers, this loss is avoided, as the circulating water is re-cooled and used over again: this entails, however, the installation of a condenser, air-pump, and circulating-pump to deliver over the cooling-tower and the cooling-tower itself.

The object in view was to design an apparatus that would condense the steam without loss of circulating water. Moreover it was desirable that the plant should be flexible, and one that could be placed in varied positions; also it should not be of great weight or occupy much room.

How far this object has been attained is now known; and results have been obtained that will in future make the evaporative condenser a fierce rival with the surface condenser and its cooling-tower.

Apparatus has been working somewhat of the form of the present horizontal evaporative condenser, but such apparatus was never designed for, and was of no use as, an evaporative condenser it being merely used as a cooler, and generally worked without an air-pump.



COMPARATIVE METHODS OF LEADING WATER OVER TUBES.

A claim has been made that such were the first evaporative condensers, but this is not the case. Several horizontal and vertical cast-iron condensers have for years been working, but the design and proportions have been such as to prohibit the extended use. This, of course, does not refer to modern cast-iron condensers, many of which are working with great success, among which the Ledward and Cooper and Grieg might be mentioned.

The first attempt in this country to introduce an evaporative condenser that would take up little space and that could be placed in any corner of the building, was one designed with vertical brass tubes, and a current of air discharged past them by an air propeller.

FIG. 6.

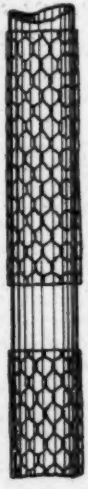


FIG. 7.

FIG. 8.

DETAILS OF VERTICAL TUBES.

Experiments have been made on a small scale with vertical copper tubes, where the water passed over the outside and the steam on the inside, and it was found that when the condensation was assisted by an air current in addition to the circulating water, that the weight of condensed steam was increased by over 50 per cent.

During the discussion on the Author's paper, "Evaporative Condensers," before the Institution of Mechanical Engineers in April, 1899, Mr. W. G. Walker said, from data he had compiled of careful experiments with condensing tubes, without the use of water, that he found 2 lbs. of steam could be condensed per square foot of tube surface per hour, with the air passing over the surface at a velocity of 1,000 ft. per second: this would give about 10 sq. ft. of surface for 20 lbs. of steam condensed per hour. About 2,400 cub. ft. of air would be required to condense 1 lb. of steam, 100 h.p. (at 20 lbs. steam per h.p) would require 1,000 sq. ft. of surface and 80,000 cub. ft. of air per minute.

In another instance, where a Ledward Evaporative Condenser was connected up to a number of engines, including a Willans of 350 h.p., it was found that the full vacuum could be maintained at 100 h.p. load without the use of any cooling water at all. In this case there was no artificial air current, but the condenser was exposed to the open air.

Also during the discussion referred to above, Mr. Michael Longridge said he had designed an Evaporative Condenser allowing 2,000 sq. ft. of surface. The maximum load on the engines was 100 i.h.p., and the highest steam consumption was about 25 lbs. per minute. This condenser in cold weather could be worked without any cooling water at all, when the load varied between 60 and 80 i.h.p.

He said from the above results that a condenser would work without water if the surface were 125 sq. ft. per lb. of steam condensed per minute, this would be without the use of a fan. The results are most interesting, as they were taken with Evaporative Condensers, and show

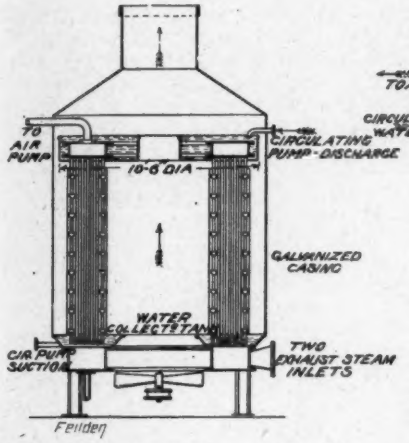


FIG. 11.—FRASER TYPE OF CIRCULAR CONDENSER.

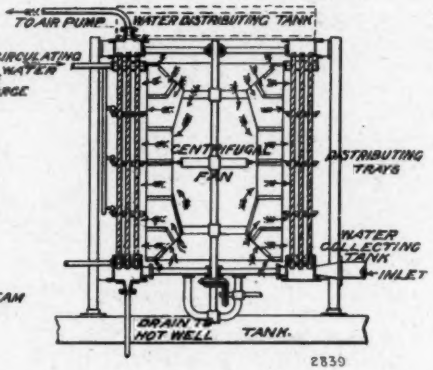


FIG. 9.—THEISEN TYPE OF CIRCULAR CONDENSER.

that, if sufficient surface is allowed, a condenser may be designed to work without any cooling water at all.

Comparing the latter case taken from practice, where 125 sq. ft. condensed 1 lb. steam per minute without an air current, with the experiments made by Mr. W. G. Walker, in which 30 sq. ft. condensed 1 lb. of steam per minute, with the use of an air current, shows strikingly the value of the air current.

These results are particularly interesting, as they show it is possible to do away with water altogether; and for some special purposes such a condenser would be valuable, as in steam road vehicles.

But in all cases of steam installations, water is required for boiler purposes, and as the evaporative condenser does not need any additional water-supply beyond this amount, there is no necessity in this case for an air condenser.

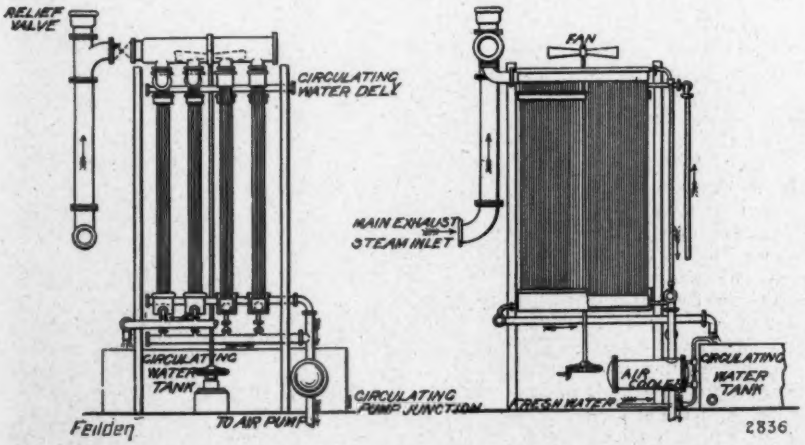


FIG. 10.—WRIGHT VERTICAL BRASS-TUBE TYPE FOR 500 H.P.

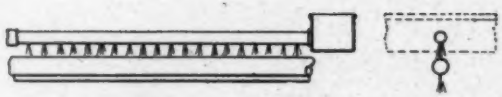


FIG. 12.—TANK WITH PERFORATED PIPE.

FIG. 13.—TANK WITH SLOTTED PIPE.

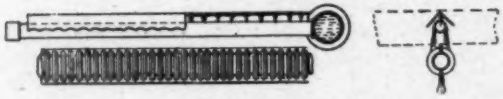


FIG. 14.—LEDWARD PERFORATED PIPE.

DISTRIBUTION OF WATER OVER TUBES.

It must be remembered also that a purely air condenser, without a fan, requires considerably more surface than a condenser working with water—over six times as much.

It will be interesting, perhaps, to mention here a condenser that has been working in London for the last 30 years, condensing all the steam from a horizontal engine indicating about 50 h.p.

The exhaust steam is delivered into a rectangular tank about 20 ft. long, 3 ft. 6 in. wide, and 12 in. deep. In the top plate of this tank, one inch (internal) diameter iron tubes are screwed. The tubes are about 12 ft. long, the upper ends are capped, the caps having a small hole in the top, to keep the condenser at atmospheric pressure. The lower ends of the tubes are in communication with the tank. The steam after entering the tank passes up these tubes, of which there are nearly 700. The condensation is effected merely by the air passing round the tubes, no vacuum is produced, the apparatus being designed only to obtain the hot feed water.

In this case there would be about 3,000, square feet of tube surface, and assuming 30 lbs. of steam per h.p., there would be for 50 h.p. a total of 1,500 lbs. steam condensed per hour.

This, worked out, gives 1 lb. of steam condensed for each 2 sq. ft. of surface, or at the figure taken in the paper (20 lbs. of steam per i.h.p.), it would be 40 sq. ft. of surface per i.h.p.

The apparatus deals efficiently with the whole of the steam from the engine.

The construction of the evaporative condenser is simple, and generally takes the form of a number of copper, brass, wrought, or cast-iron tubes arranged either horizontally or vertically.

The steam to be condensed passes through the inside of the tubes and the circulating water over the outside.

Before any steam can be condensed, inside the apparatus, its latent heat must be given up, and, in the case of an evaporative condenser, it is given up to the circulating water on the outside of the tubes. The total number of thermal units contained in 1 lb. of steam at the condenser temperature is approximately 1,000. Therefore, for each pound of steam condensed, these 1,000 units of heat are abstracted and communicated to the circulating water converting it into steam.

It will be seen then that one pound of circulating water is all that is theoretically required to condense each pound of steam; *i.e.* the circulating water lost should be equal to the boiler feed.

But in practice it is found that the circulating water lost by evaporation is much less than the boiler feed, from the fact that a certain proportion of the heat is communicated to the surrounding air and carried away, this amount being greater on a windy day.

Radiation and conduction are other causes that lower the condenser temperature.

From these causes the quantity of circulating water evaporated is reduced by 25 per cent. in condensers having a minimum of surface, and by 50 per cent. where a larger surface is employed; a

considerable further reduction of the quantity of circulating water may be effected, but it is not desirable to do so for general purposes, as we then get the air condenser with its increased surface.

An evaporative condenser necessarily has more surface in it than has a surface condenser, but it must be remembered that the evaporative condenser (per square foot of surface) does nearly ten times the amount of work.

It is apparent then from the previous observations that the type of condenser with which this article deals is capable of great flexibility, it can be adapted to and worked under almost any condition, and its life compares favourably with any other type of condenser.

The attempt to produce a condenser that would occupy little space, and moreover one that would not use any more water than that required for the boiler feed, brought into use the vertical brass tube condenser.

This condenser consisted of an upper chamber and lower chamber. These chambers were annular and about 12 ft. apart, this being the length of the tubes which were jointed into each chamber; the chambers being, of course, one above the other. The steam was admitted into the lower chamber and passed up the tubes. On the outside of the tubes the circulating water flowed down, *i.e.* in an opposite direction to the course of the steam. It is here that the condensation takes place—the heat of the exhaust steam being transmitted through the tubes to the circulating water, evaporating a great portion of it.

The steam is condensed inside the tube and falls by gravity to the lower chamber. When the condenser is fixed more than 30 ft. above the hot well, this

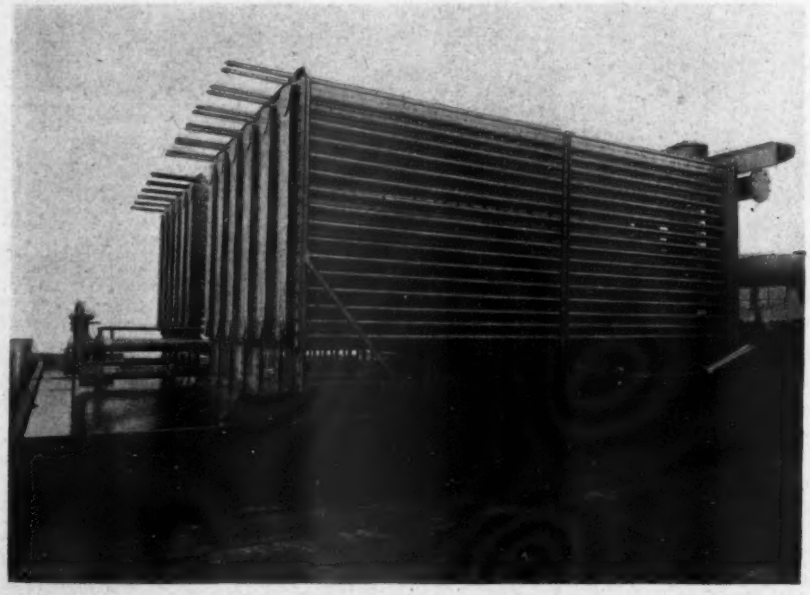


FIG. 15.—SIDE VIEW OF 1600 H.P. FRASER'S PATENT EVAPORATIVE CONDENSER.

Photograph shows two sections, 800 h.p. each, six layers of tubes each section. Loss of water by evaporation equals half the weight of steam condensed. Vacuum 24. Results obtained from six months' working tests with water motors.

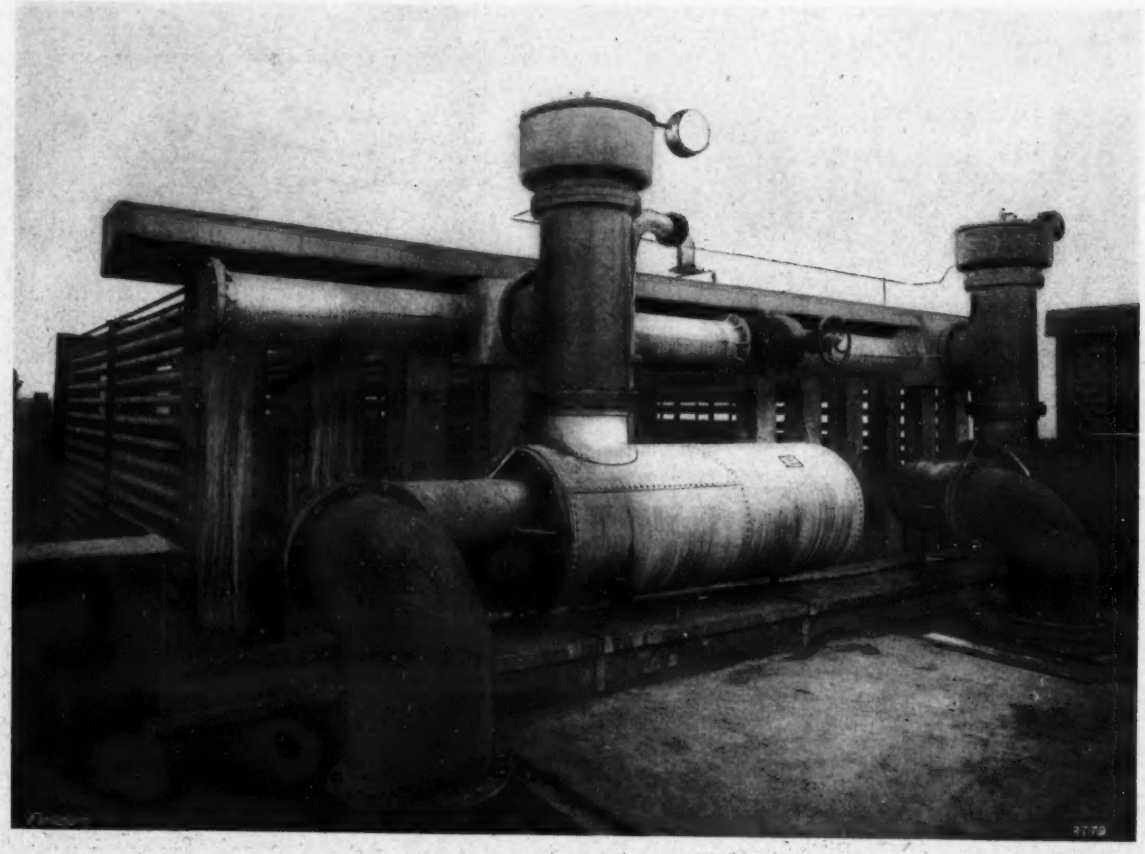


FIG. 16.—FRASER EVAPORATIVE CONDENSER.

View of steam inlets. 800 i.h.p. Condenser in two sections: six layers of tubes each section. Vacuum at full load 24 ins.

condensed steam may be carried off by means of a pipe taken from this lower chamber to beneath the surface of the water in the hot well. A column of water is maintained in this pipe depending upon the height of the barometer, but if the condenser is at the elevation mentioned, then the surface of the water in this is always below the lower chamber of the condenser, which is thus perfectly drained. A pipe to the air-pump is taken from the top of the condenser.

Immediately under the top steam chamber was suspended a tank into which the circulating water was pumped. Holes were drilled in the bottom of this tank for the tubes to pass through, the holes being larger than the tubes. This left an annular space through which the cooling water flowed. This is clearly explained by reference to the Figs. 1 to 5. The raised bush and lip are to prevent any solid matter or obstruction passing into and choking the annular space. It was found that the water, when flowing down a plain tube, broke up into trickles and eddies, so that in some places the tubes were bare of circulating water. To remedy this, various devices were fixed upon the tubes as shewn in Figs. 6, 7 and 8, to give an even distribution and keep the water in close contact with the tubes. Latterly a special fabric was wrapped round the tubes; this answered very well in keeping the water against the tubes, but it was found that this rotted, and portions were eventually found in the circulating water. Water was sprayed upon the tubes, under pressure, but this did not give very high results. The circulating water, after passing down the tubes, is collected by a tank and pumped again over the tubes.

It will be seen, by this method of steam and water circulation, that the hot steam entering at the bottom comes in contact with the hottest circulating water, and the coldest water meets the

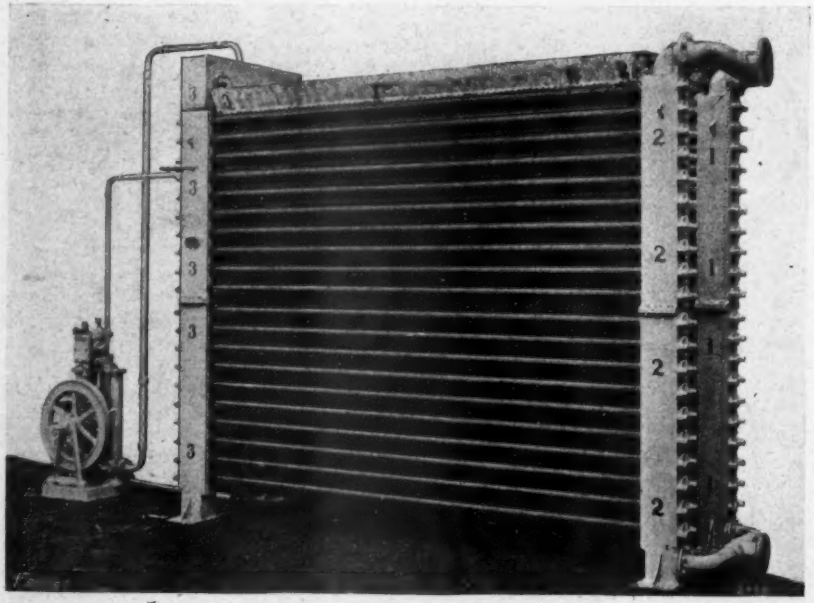


FIG. 16A.—100 H.P. KIRKCALDY CONDENSER, FOR USE WHERE CIRCULATION WATER IS SCARCE AS IN PLACES ABROAD.

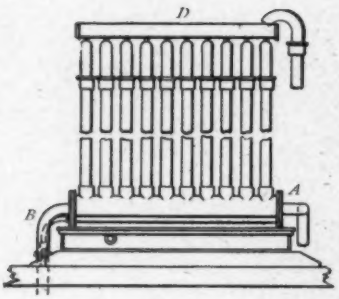


FIG. 17.

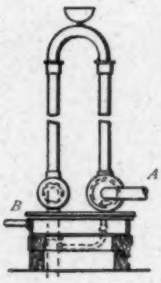


FIG. 18.

VERTICAL CAST-IRON TUBE OPEN-AIR TYPE OF CONDENSER.

lower temperature steam,—a desirable condition.

The fan was placed below the condenser and delivered the air through the central space between the concentric rings of tubes. In later designs the fan was placed at the top so as to suck the air past the tubes; the condenser should then be incased at the top, so that the air may be drawn in at the lower part of the tubes.

In the Theisen condenser a fan of special construction was used which delivered the air approximately at right angles to the tubes, the driving spindle of the fan being parallel to and concentric with the condensing brass tubes.

The fans were run at a high speed, but this was found to drive the water off the tubes; it was therefore found necessary to reduce this speed.

The surface of brass tube, measured on the external circumference, originally allowed, was 1 sq. ft. per 10 lbs. of steam condensed per hour, but condensers with this amount of surface did not give good results, and by stages the surface was increased to 1 sq. ft. per 6 lbs. of steam condensed per hour.

This type of condenser is certainly not giving those results that were anticipated, although several are at work and reducing considerably the yearly cost of the coal bill.

It is quite possible for an evaporative condenser to be constructed with no more surface than a surface condenser, and when the method of water distribution is improved, and the fans arranged so that they give a perfect air circulation round the tubes, there is no doubt that it (the vertical brass-tube condenser with fan) will be a useful apparatus to adopt. The ground space occupied would be about 1 sq. ft. per 6 to 10 h.p. in large sizes.

The crowding up of the tubes unfortunately does not give sufficient room for cleaning purposes.

Three condensers of this type are illustrated in Figs. 9, 10, and 11, and are respectively the Theisen, Wright, and Fraser. The Wright Condenser will be seen to be constructed with rectangular boxes, with the steam entering at the top, and the air pump connected to the lower chamber.

The difficulties that were experienced with the *vertical brass tube* condensers led to the adoption of the *horizontal* and *vertical open type* condenser, with either cast or wrought-iron and copper tubes. In this type of evaporative condenser the space occupied is necessarily greater than with *vertical brass tube* condenser.

In the first place, considerably more surface is allowed for cleaning: in fact, a man can easily walk all round the apparatus and reach every tube.

This type can comfortably be placed within the space occupied by the engine sets to which they are connected. So that, if placed upon a roof, they could be placed immediately over these sets, the centre lines of each apparatus corresponding. The space occupied by a horizontal condenser with wrought-iron or copper tubes would be about 1 sq. ft. per 2 to 3 h.p. The space occupied by cast-iron condensers is a little in excess of this.

With this ground space the height would not be more than 10 ft., this also being about the height to which the circulating water would have to be raised. In wrought-iron tube condensers each square foot of tube surface will easily condense 2 to 3 lbs. of steam per hour,

and with cast-iron tubes about 1½ lbs. steam per hour. The surface given depends also on the general arrangement of the condenser, pipe connections and water circulation. The circulation over the horizontal tubes is practically perfect.

Various methods of distributing the water over the tubes are used: two methods adopted are those shown in Figs. 12 and 13. The circulating water is pumped into the tank shown, from this tank slotted or perforated pipes are taken, one above each vertical stack of tubes. The strip under the tube is to collect the water centrally for delivery over the next lower tube, this strip need only be fixed on the top tube. The distributing pipe of the Ledward Condenser is shown in Fig. 14.

The water circulation in this type of condenser causes no trouble whatever. After the air and circulating pump are started the steam from the main engines is then turned into the condenser. The apparatus then requires no more looking after till the engines are shut down. Scale of course is deposited upon the tubes, but causes very little trouble, as it is easily removed. And in the case where copper tubes are used the condenser is almost self-cleaning, as the scale is continually flaking and dropping off. It is found also that a good method to remove hard scale, is to turn the steam into the condenser; when the difference in the expansion between the copper and the scale, causes the latter to fly off, leaving a practically clean surface.

Figs. 15 and 16 show two views of the Fraser patent evaporative condenser. Two sets are shown, and each set is connected up to a Willans engine of about 800 h.p. During the last two years the condenser has been producing a steady vacuum of 24 ins. in connection with an electric light station in London. The tubes are of solid drawn copper 3 ins. in diameter. The condenser is erected upon the roof.

FIG. 10.—1200-H.P. CONDENSER BY MESSRS. COOPER AND GREIG.

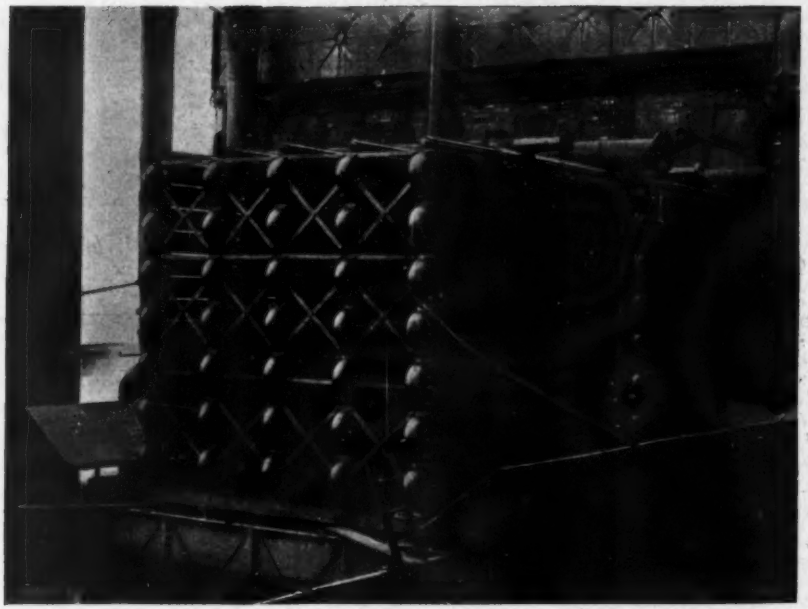


FIG. 20.—A LEDWARD EVAPORATIVE CONDENSER.

The exhaust pipes from the engines are shown, the circular vessels are the oil separators.

The steam is delivered into the top of the condenser and the air-pump pipes are taken from the bottom. The air pumps are in the engine-room 30 ft. below the condenser, the circulating pumps being only a few feet below the condenser. The air and circulating pumps are electrically driven.

The make-up water passes through a meter which showed during the period of running that the loss due to evaporation was considerably less than the boiler feed.

The steam does not pass through the whole of the tubes in parallel, but first passes through six to the opposite end of the condenser, and then returns through a smaller number; and so, backwards and forwards, till it finally reaches the bottom. This ensures complete condensation.

The oil separator, as will be seen, separates the oil from the steam, before the latter passes into the condenser: this is by far the most effective way of dealing with it, as it removes almost all the oil. The separator is drained by means of a barometric pipe which is led to a catch-tank about 30 ft. below the level of the condenser.

The oil returns perfectly clear, as a sample from the catch tank proved.

In fig. 16A a Kirkcaldy condenser is shown capable of dealing with 100 h.p. These are used for condensing steam where cooling water is scarce, more particularly abroad. The circulating pump is shown, and an air pump can be fitted if required.

Another type of evaporative condenser, which may be described as the vertical open-air type with a free water distribution, is the one shown in Figs. 17 and 18.

The construction consists of two cast-iron vertical tubes connected together at the top by a bend, the lower portion of

each leg being jointed to the horizontal pipes shown.

The steam is admitted at *A* and passes along the larger horizontal pipe, and from thence up the vertical pipes or legs, over the bends, and finally down the remaining legs to the smaller horizontal pipe *B*, and from there to the air pump.

The circulating water is pumped into the trough *D*, which has holes in it immediately above the bends on each pair of legs, which allows the water to flow over the bends and down the vertical pipes to the collecting tank from which it is pumped again over the tubes.

This condenser is extremely simple in construction, and can be easily and readily cleaned. The condenser shown is of small capacity, but they are made of much greater capacity by increasing the length of the horizontal pipe and the number of legs.

A number of these sections can be formed on to a battery above the engine-house, or each section can be placed on existing roofs between the angles so as not to interfere with the light.

The illustration in Fig. 19 is taken from a photograph of a plant at present in full working order. This plant is dealing with about 1,200 h.p. in connection with an electric-light station.

A vacuum can be maintained with this apparatus of 24 ins. to 28 ins. of mercury.

It will be seen that ample space is provided between the sections for inspection and cleaning. This type is designed and manufactured by Messrs. Cooper & Grieg, of Dundee, and some tests were made (with a condenser of their make) in which, under rather unfavourable conditions, it was shown that the water lost by evaporation was only three quarters of the boiler feed water.

The illustration, Fig. 20, is the Ledward Condenser; the plant shown is now working at Messrs. Whitwell & Co's., Thornaby-on-Tees.

The construction consists of a number of corrugated cast-iron tubes connected together by bends at each end, the whole forming one continuous pipe, and may be called a section. Any number of these sections may be placed together to deal with the amount of steam required to be condensed.

The exhaust steam enters at the top, and passes backwards and forwards through the corrugated pipes, and is drawn off to the air pump at the lowest point in the condenser.

Two views of the Ledward Patent Evaporative Condenser, now working at the Chapel Street station of the Kensington and Knightsbridge Electric Light Company, are shown in Figs. 21 and 22.

These tubes are 5 ins. diameter inside and $\frac{3}{8}$ thick, and in the condenser there are 540 tubes, each tube being 5 ft. long; the total surface exposed being about 11,800 sq. ft.

The quantity of water circulated is 30,000 gals. per hour, when the maximum load was 26,000 lbs. of steam per hour.

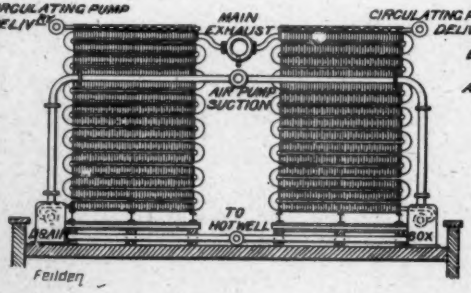


FIG. 21.

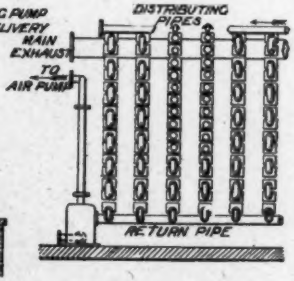


FIG. 22.

DETAILS OF A LEDWARD EVAPORATIVE CONDENSER.

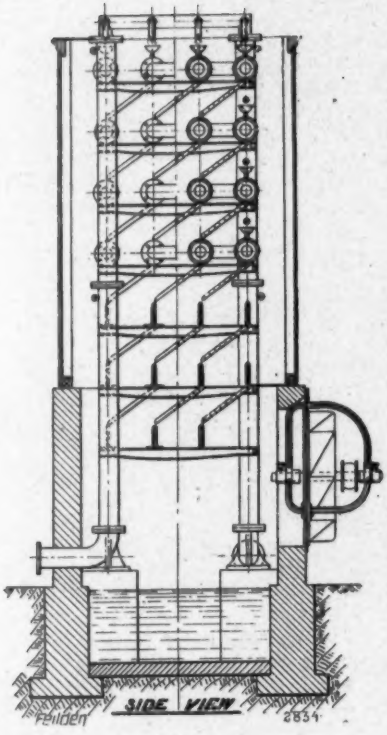


FIG. 23.

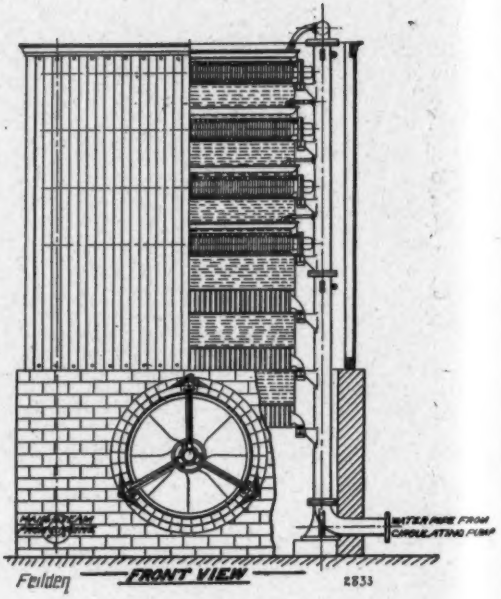


FIG. 24.

LEDWARD'S PATENT EVAPORATIVE CONDENSER IN WHICH A FAN IS USED.

The condenser was designed for 20,000 lbs. of steam per hour, and the vacuum at the air pumps during this load was about 26 ins.

It will be seen that at the maximum load the condenser was overloaded, but continued to do its work well, but, of course, with a drop in the mercury gauge.

In connection with this plant a set of Edwards' electrically driven air-pumps are installed. The pumps were three-throw taking about 5 b.h.p. at normal load.

If it is desired to reduce ground space, the design shown in Figs. 23 and 24 may be adopted, in which a fan is used.

It will be seen that the cooling water, before reaching the catch tank, passes over a series of plates; this exposes the water to the incoming air and so reduces its temperature.

The most efficient arrangement of the evaporative condenser is to place the apparatus on the engine or boiler house roof. The pipe connections are then extremely simple and of a minimum length.

The two views in Figs. 25 and 26 are typical of the latest practice for stations specially designed, and a similar design may be followed when installing evaporative condensing plant in existing premises. It will be seen that the exhaust pipes from the engines are carried straight up against the engine-room wall and thence to an oil separator, connection being made from this separator directly to the condenser.

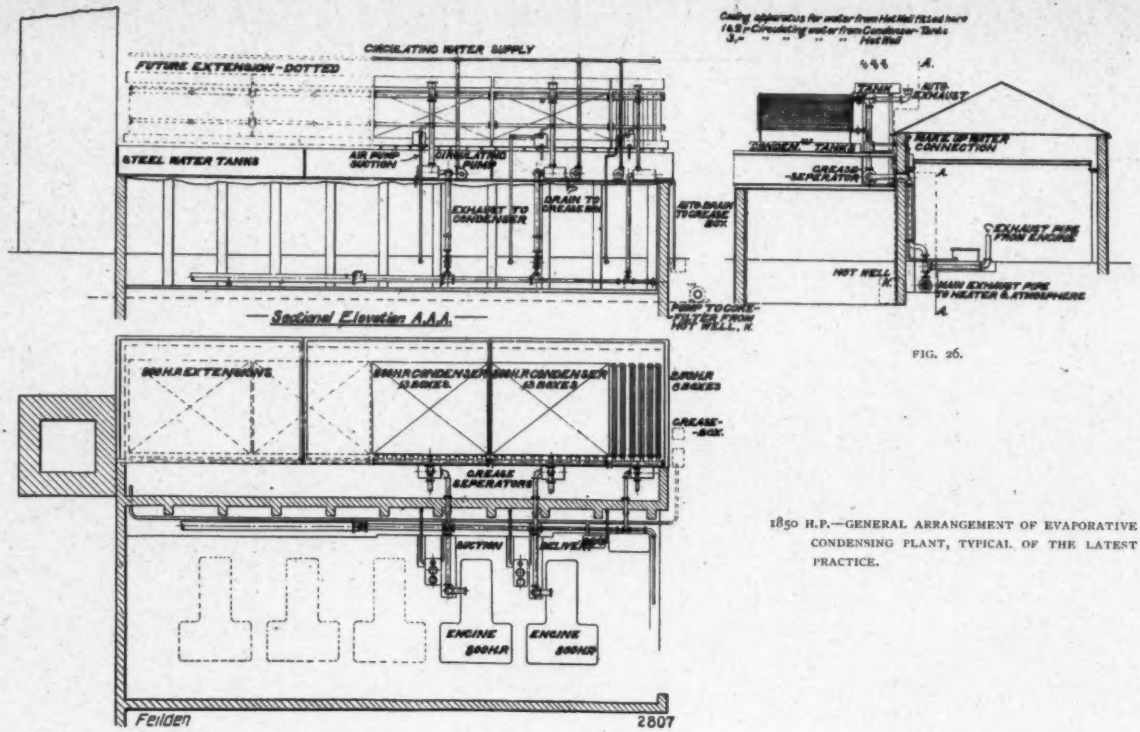


FIG 25

FIG. 26.

1850 H.P.—GENERAL ARRANGEMENT OF EVAPORATIVE CONDENSING PLANT, TYPICAL OF THE LATEST PRACTICE.

The air pumps are in the engine-room, and the circulating pumps on a level with the condenser, both of these auxiliaries are electrically driven. This arrangement is that adopted by Messrs. John Fraser & Son, Millwall Boiler Works, who, it may be mentioned, pay special attention to the arrangement of their pipe and pump connections.

It cannot be too strongly impressed upon steam users adopting any condensing plant, that the exhaust main must be well designed and submitted to an efficient test before being set to work.

Considerable trouble has been caused through this precaution being neglected. All joints must be carefully machined and made in the best possible manner, and the whole apparatus, including condenser and connections, should be subjected to a water test and made perfectly sound: if this is done no fear need be entertained on the score of loss of vacuum or bad working.

The water from an evaporative condenser may be used again as boiler feed. The exhaust steam should pass through a separator before it enters the condenser, by this means nearly the whole of the oil may be removed. Such separators are of simple construction and work efficiently, and are decidedly better than other types that filter through obstructive and perishable mediums after the water has passed through the condenser.

Moreover the condenser is kept perfectly clean inside.

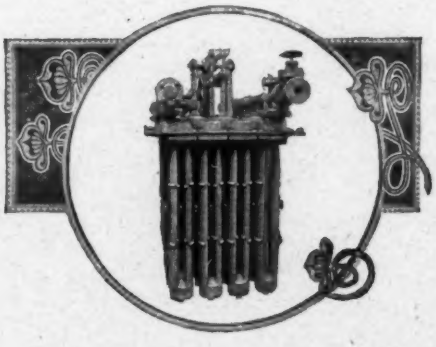
It must not be forgotten the steam passes at a high velocity through the exhaust main, and the separator should be of ample size so as to reduce this velocity. By this means, and suitable baffles, the oil is arrested.

No condensing plant can work successfully if an efficient air-pump is not provided. Those types with two or three throw-cranks—those of the vertical type working from a beam—are of the most modern type. The single acting pump with one cylinder, where the load is uneven on the up and down stroke, is effete as regards modern condensing plants. The Edwards air-pump is doing good service; the high speed at which it may be run allows it to be smaller in dimensions than a slow running pump.

The ordinary centrifugal pump is generally used for circulating purposes.

It may be taken for the purposes of this article that 1 h.p. is developed from 20 lbs. of steam per hour.

Henry G. Vaughan



Recent Developments in Lighthouse Engineering.

By JOHN A. PURVES, D.Sc., F.R.S.E., M.I.E.S.

In the early days of lighthouse illumination, when our coasts were but scantily supplied with lighthouse stations, which were situated at great distances apart, the old fixed lights were all that could be desired and served their purpose well; but as the number of lights increased it was found necessary to furnish some distinction between one light and another, so as to guide the mariner upon his way in safety, and this end was in a large measure accomplished by the introduction of the revolving and occulting lights.

The revolving light, as will be seen from a glance at the Admiralty list of lights, was until very recently the favourite form of apparatus. For this reason the older fixed lights have in a great many instances been altered to occulting or intermittent lights, either by the addition of racks of revolving vertical prisms, or still more commonly by the application of a mechanical shutter or eclipser which rose and fell over the illuminant.

The simple revolving light has however not been able to cope with the increased demand for distinctive characteristics now required by the lighthouse service. This difficulty has however been met most successfully by Dr. Hopkinson's group-flashing system now so universally adopted in our newer lights.

It may not be out of place here to remark that the group-flashing system consists essentially in splitting up the large beam emitted by a side of a revolving apparatus into several smaller beams, each beam being separated from its neighbour by a very small interval of darkness, while the group of beams is separated from its contiguous group by a relatively long interval of darkness.

The group-flashing system, good in so many ways, has one serious disadvantage; which is, that a well-marked and distinctive characteristic is obtained at the expense of power of beam.

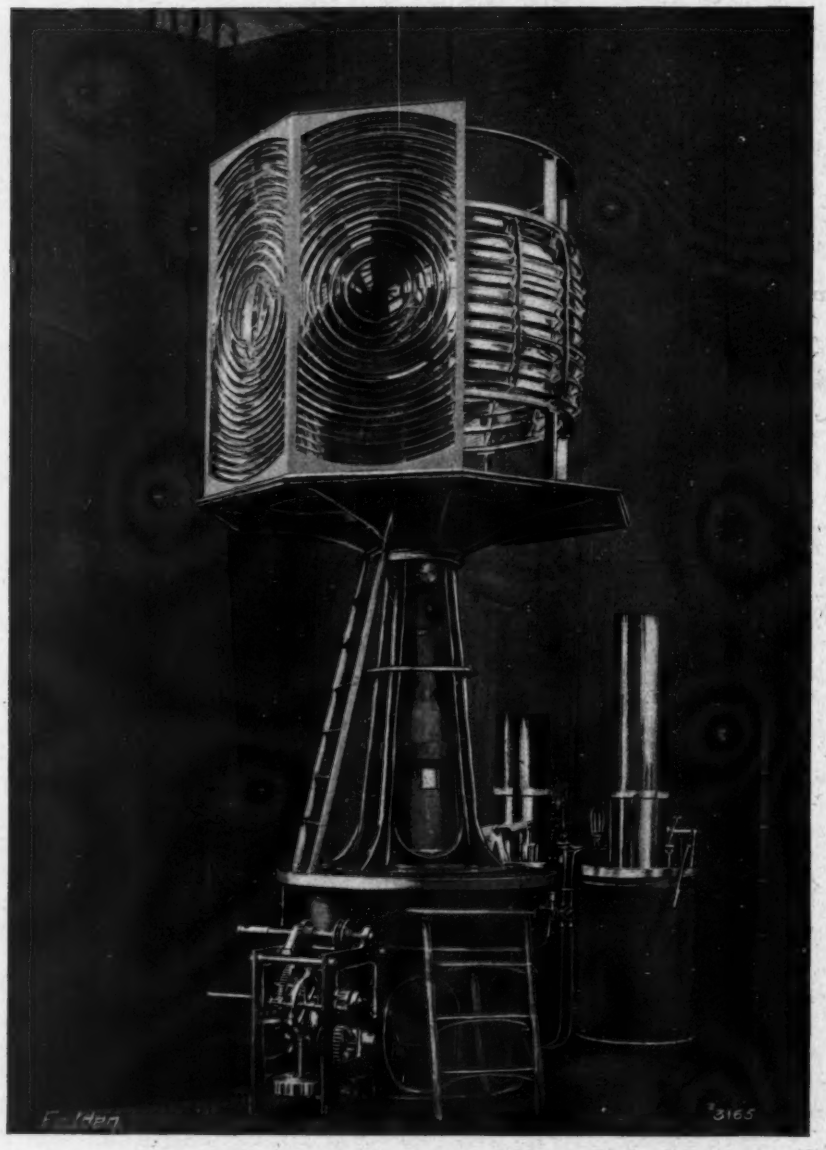
This is necessarily so, as the power of the emergent beam is a direct function of the number of beams employed. The beams are further necessarily weakened in most cases by having a larger proportion of reflecting prisms than in the single-flash panel.

As an example, we may take a four-sided apparatus each side of which forms groups of two flashes. This apparatus has therefore a beam the power of which is approximately equal to that given from an apparatus of eight sides.

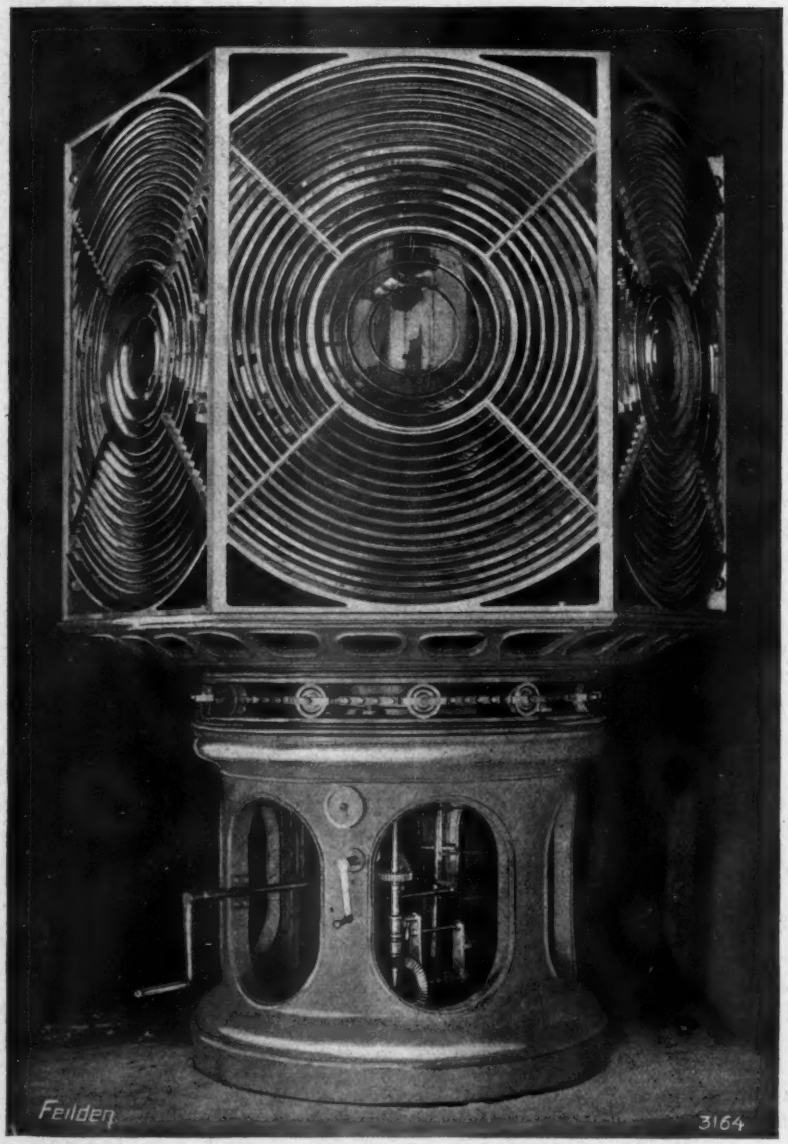
This disadvantage has to a large measure been overcome in France and elsewhere by the use of the feux-éclairs system which was rendered possible by the introduction of the mercury-float mechanism by the late M. Bourdelles, Director General of the Central Lighthouse Service of France in 1890; and, indeed, the development of the modern system of lighthouse apparatus and illumination may be said to date from this period.

In place of the roller or ball bearings employed in the past for revolving apparatus, an annular trough is employed, in which there floats a second annular trough, on which is carried the dioptric apparatus. In order to steady the revolving superstructure, and to render it capable of a certain amount of adjustment, a vertical spindle projects downwards from the apparatus through the mercury trough to some distance below it, and is supported and guided upon suitable bearings.

Such is briefly the invention of the mercury-float mechanism, and it is clear



FIRST ORDER QUADRUPLE FLASHING LIGHT, 920 M/M FOCAL DISTANCE WITH DIOPTRIC MIRROR AND MERCURY FLOAT CARRIAGE. DESIGNED BY W. T. DOUGLASS, M.INST.C.E. AND CONSTRUCTED BY CHANCE BROS. & CO., LTD., FOR HOOD POINT, CAPE OF GOOD HOPE.



SINGLE-FLASHING HYPER-RADIAL APPARATUS, SIX SIDES, 80 DEGS. VERTICAL ANGLE, CONSTRUCTED FOR THE SPURN HEAD LIGHTHOUSE, BY CHANCE BROS. & CO., LTD.

that, with only fluid friction to contend with, the revolution of the apparatus is rendered easy in the extreme, and that a speed and steadiness of revolution are obtained that were impossible with the older forms of apparatus.

Having devised an apparatus capable of such rapidity of revolution, M. Bourdelles was led to the conclusion that, by reducing the number of sides in a revolving apparatus, and so allowing of an increased size, it would be possible, with the rapidly revolving mechanism, to produce flashes of great power, following one another at short intervals, as had been done with the old manysided apparatus; and hence arose the feux-éclairs or lightning-flash lights, now so generally employed.

This system, it will thus be seen, makes use of dioptric panels of the greatest possible amplitude, which are revolved at a speed limited only by the duration of flash necessary to give to the eye of the mariner the full perception of the light emanating therefrom. In practice this was found to be about one-tenth of a second for lighthouse purposes.

FOURTH ORDER DOUBLE-FLASHING LIGHT, SHOWING TWO QUICK FLASHES EVERY 15 SECONDS, WITH REVOLVING CARRIAGE OF BALL-BEARING TYPE.

The first mercury-float feu-éclair light which was established was that at Senetose, in the island of Corsica, in the year 1890.

As a further advance in lighthouse apparatus, the twin mercury-float feu-éclair may be mentioned. Here, instead of the superposed biform, triform or quadriform apparatus previously used, the two apparatus are placed side by side, and are so set that the flashes from one apparatus are parallel to those from the other, so that at sea the beams are, in effect, one.

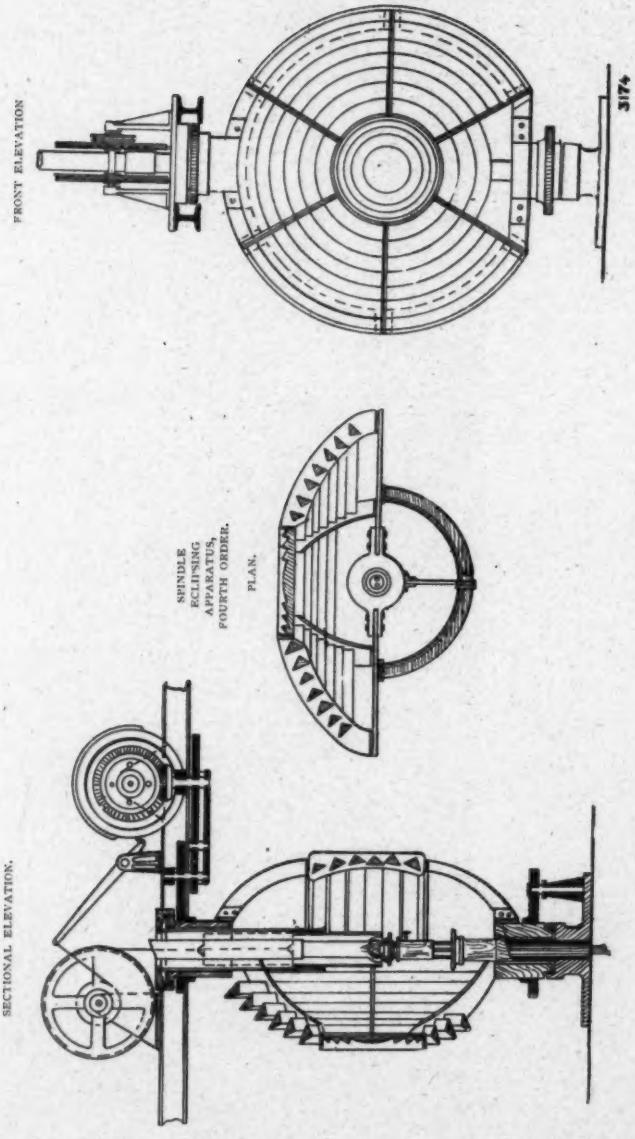
The desirability of having the lights round our coast distinctly differentiated from one another, so that no possible mistake can be made by the mariner, is obvious to every one; and this end can be attained so far as distinctive characteristics go, by an extension of

the group-flashing system in conjunction with the French system of the feux-éclairs. In order to obviate the disadvantages of the group-flashing system the writer was led to devise the form of lighthouse apparatus now known as the spindle eclipser. As has been pointed out, it was customary in the past to employ a shutter eclipser or other device whereby the light from the illuminant could be cut off, in conjunction with the old fixed form of apparatus, in order to produce flashes or occultations. This system of mechanically producing flashes has been very largely used in England and elsewhere; and the writer was struck by the idea that, by employing such mechanical shutters eclipser or the like in conjunction with a single revolving panel, he should be able to produce all that can be accomplished by a group-flashing apparatus without any loss of light whatsoever. The apparatus consists essentially of a single dioptric panel in the focus of which is one of the ordinary well known oil lamps. This panel is of the greatest possible amplitude, *i.e.* 180 degs. in azimuth and 180 degs. in altitude. Occupying the remaining 180 degs. of azimuth, is a dioptric mirror; and this combination of elements is at once the most powerful and compact form of lighthouse apparatus which it is possible to design.

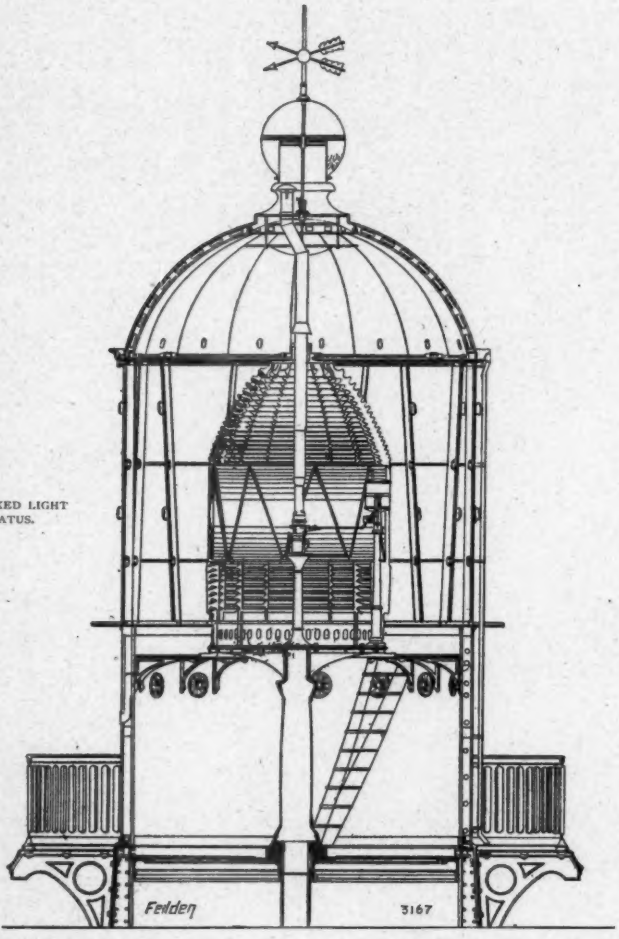
(A) HOLOPHOTAL TRIPLE-FLASHING (B) REVOLVING LIGHT OF THE 4TH ORDER.

Suppose a group-flashing light is required, each group having two flashes; all that is required is to so design the mechanism of the eclipser that it will eclipse the light after two complete all-round flashes, remain closed for the length of time required for the long dark period between the groups, and then open just long enough to allow the two flashes to be seen once more, and so on *ad infinitum*.

In place of only one panel Mr. W. T. Purves has shown that two can be used; but here it is necessary to have the eclipser



SPINDLE ECLIPSING APPARATUS, FOURTH ORDER.



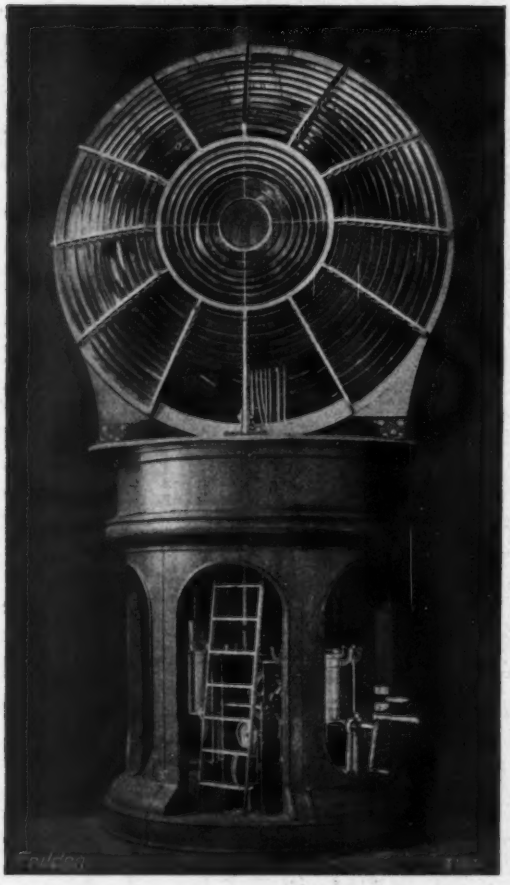
PURVES FIXED LIGHT APPARATUS.

in two halves, each of which is operated separately, so as to obscure in rotation the light from one panel and then the next.

From what has been said, it is clear that with only one, or at most two, simple dioptric panels and an eclipse it is possible to produce all manner of group-flashing characteristics which in the past demanded the splitting up of the large panels into sections from each of which a beam emanated.

This system permits if desired of a systematised series of flash characteristics following one another in sequence round the coast, and it also permits of carrying out the system adopted in the United States of signalling numbers and this without any sacrifice in power of light.

This method can also be used to give greater prominence to the idea of making the duration of darkness a distinctive feature in a flashing light; and this is rendered more desirable as, in the quick



FIRST ORDER LIGHT, 920 M/M FOCAL DISTANCE, ON THE "FEU ÉCLAIR" SYSTEM, WITH MERCURY FLOAT. GIVING A SINGLE FLASH EVERY FIVE SECONDS; DURATION OF FLASH 0·2 SECOND. CONSTRUCTED BY CHANCE BROS. & CO., LTD., FOR CAPE LEEUWIN LIGHTHOUSE, WESTERN AUSTRALIA.

flashing lights, the duration of light can not be made characteristic.

This system possesses many advantages from an economic point of view. It permits of small apparatus being used and consequently of small lanterns and accessories. It permits of smaller burners being used and consequently of less consumption of oil, although this is a small matter. But the great saving consists in this, that, as one standard form of apparatus would serve every purpose, new designs would not need to be prepared for every new light, and therefore new and extensive dioptric elements would not need to be calculated, moulded and ground. It may further be remarked that, by using such standard light as say a third order for our 1st, 2nd, and 3rd class lights, our mariners would not be perplexed by the endless variations of the power of our lights as given in the Admiralty lists of lights. All these would have the same intensity of beam, whatever number of flashes they might have; all would have an equal luminous range in clear weather and penetrating power in fog; and all an equal geographical range, so far as the power of light is concerned.

John A. Purves

The Mathematical Laws Governing the Development of Profit in Industry and Commerce.

By Professor R. H. SMITH.

The Bills introduced recently into Parliament upon the subjects of Money-lending, of Secret Commissions, and of the General Regulation of Company Promotion and Direction; the bankruptcy scandals in the Courts and outside them; and the ever-quickening march in the direction of very large manufacturing and trading combinations, are all illustrations of the ferment and fever which has of late years taken more and more hold upon British financial enterprise. Much of this is clear evidence of a thoroughly unwholesome condition. Let us hope it does not prove the existence of a rottenness from which there is no recovery except through death and Phœnix-like re-birth, and that the frank recognition of the evils that have become so prevalent will stimulate the nation to adopt such cures as will before long establish British enterprise upon an even more healthy and more vigorous basis than it ever before stood upon. Dishonesty and unscrupulousness are unhappily more in evidence in this decade of our business life than probably ever appeared in the past of English history, and this canker must be cut out with the knife before the new healthy life has a chance to grow. But, on the other hand, it ought to be admitted that a great degree of restlessness, confusion, and hysterical violence of oscillation between the extremes of speculation and of prudence is only natural and unavoidable in this age, which is undoubtedly one of very rapid change and improvement in industrial methods and of opening out of new spheres of activity. We see American manufacturers outstripping us in several directions, and some German ones doing likewise in, at least, some directions; and we know that this is due, certainly in the case of the United States, and probably also in a certain degree as regards the Germans, to the vigour of their enterprising spirit, and not to greater ability or manipulative skill possessed by either their professional men or their artisans. On the other hand, we know that the marvellous success of British industry in the past has been mostly the result of the doggedly cautious and practical manner in which our leading men have followed the guidance of ascertained experience and nothing else.

In bygone days the managers of works were, for the most part, the men who furnished the money with which to run them. As financial combinations have become larger, the holding of the capital has become gradually divorced from the skilled knowledge that directs it, until now the investor as a rule has absolutely no detail or technical acquaintance with the work done by help of his capital. On the other hand, the accumulation of capital and consequent reduction of interest on capital naturally produces an eager competition of investors which does nothing to encourage the careful and critical examination of the real prospects of genuine profit.

Thus, on the one hand, the rapidity of the introduction of new methods and new kinds of work makes past experience a less sufficient guide than formerly; while, on the other hand, those seeking utilisation of their capital, supply greatly less technical and scientific skill for its management. This condition of things inevitably

results in much blind and febrile feebleness and in a certain amount of authority being placed in the hands of shallow-pated sharpers. The aim of this paper is to encourage sober consideration of the fundamental principles of profitable business, and thus contribute towards the much-needed defences against these vicious tendencies.

The legitimate expenses of the promotion and formation of modern large companies are much heavier than in former days, and the fight to maintain position in the midst of fierce competition makes the proportion of necessary annual expenditure that is not spent on directly productive work, for instance the necessary outlay on advertisement in its innumerable forms, very much larger.

The press of these conflicting forces has produced many very doubtful results. Among these may be particularly noted the practice, now not infrequently met with, of paying dividends out of capital: a practice which is often defended as legitimate in certain circumstances, but one at the bare suggestion of which safe business men of the past generation would have stood aghast.

This practice exists more commonly than is either avowed or recognised by the shareholders receiving the dividend. In multitudes of cases, not of the evidently bad class, the whole question as to whether the dividend is being actually paid out of capital or out of earned income depends entirely upon whether or not a rational and fair amount of depreciation is being written off. It is impossible in any case to calculate with real exactitude—an apparent exactitude is always easy to arrive at by artificial methods—what is the rational and fair annual depreciation. It is easy without risk of scandal to express, and to argue in favour of, very widely different opinions as to the fair allowance for depreciation. As accuracy in the estimate is rationally unattainable, it is quite clear that there is room for a material difference between perfectly honest and even skilled judgments. But the writer cannot see that any extremely large variation of honest and impartial estimate in this matter can arise among people having real technical knowledge and skill in the particular trade or manufacture concerned, provided always that there be no mere quarrel over the meaning of words.

If there be an account of "Maintenance, Renewals, and Repairs," and another of "Depreciation," it is certain that as more is placed under either of these heads the less will there be to fairly place under the other. It is a matter of comparatively small importance whether many items be included in the one or the other of these two accounts; but, outside the limits of two special matters, there appears no ground for serious difference between real experts as to the sum of the two accounts. As regards renewals that are entire replacements, the most straightforward and just plan must be to charge these to capital account, at the same time writing off as depreciation the total value of the displaced plant.

The first of these special matters is one on which there was recently some rather acrid recrimination. It relates to the provision of a reserve fund to cover intermittent heavy repairs and renewals—such renewals as are not needed every year. It is certainly the just aim of prudent finance to distribute the cost of these as equably as may be over all years, and the obvious way to do so is to make an annual contribution to a reserve fund for this special purpose and to pay the cost of them out of this fund. If they are distinctly foreseen and pre-calculable amounts, there seems to be no good excuse for not following this plan. In so far as they may be due to unforeseen accident, no one could have a right to dogmatise on the subject, but even here it may be pointed out that the principle of insurance is in nearly all cases applicable, and is actually and habitually applied with regard to very many kinds of plant; for instance, to boilers as against explosion, to ships as against loss at sea, and to buildings and other property as against fire.

A more uncertain element in the depreciation account is that due to "antiquation." This represents a far more serious real loss

to capital in recent years than it used to do when improvement in pattern and efficiency was a great deal slower than now, and when entirely new departures due to scientific discoveries were few and far between. A machine may be very little worn out, may be in good repair and working condition, may produce as much work of as good quality as it has done in previous years, may, indeed, have an almost undiminished earning capacily; yet it may suddenly lose a quarter or half its capital value by there being placed on the market a new design of machine for three-quarters or half its price, but doing the same quantity of work of the same quality. The yearly fair allowance for antiquation must evidently be speculative if it be made before the actual appearance of the superseding design, and probably most capitalists will be content with the writing off of the loss after it has actually occurred. But the theory is sometimes upheld that no antiquation depreciation is called for under any circumstances so long as, and in so far as, the machine maintains its original efficiency and earning capacity. There need be no hesitation in condemning this theory as essentially false and deceptive.

Whatever be the kind of business embarked on, there must always be a certain initial expenditure on capital account before the receipt of any revenue. Even those who buy stocks and shares on the exchange without having any funds to pay for them, must have spent beforehand something in working up a reputation enabling them to do so. The ratio of such initial capital outlay to the general magnitude of the operations afterwards carried out varies, of course, immensely in different trades and professions, but some such outlay is unavoidable. In course of time, as revenue develops from its starting point, further capital outlay is nearly always required, although in special cases nothing further may be needed for a considerable period.

The same statement is true of current expenditure. Annual expenditure, often on a very considerable scale, must be arranged for before the commencement of any return in the shape of revenue. Rent and management salaries will be the largest items in this initial annual expense. As revenue increases, so also must the annual expenditure involved in earning it. The rate at which these current or working expenses rise at first as compared with their initial amount is, or ought to be, much greater than is that at which capital outlay increases as compared with the initial capital outlay.

The growth of these two classes of expenditure is clearly and simply followed if they are plotted as vertical ordinates to two lines in a diagram whose base line measures the increasing gross revenue. Fig. 1 is a sketch of such a diagram. The upper, or capital outlay, line starts at a considerable height, and usually at a very small slope, which afterwards increases for a time, the line rising with a degree of irregularity and step-up intermittency which depends entirely on the character of the work. The lower line, giving the current or working expenses, starts at a much lower level, but with a relatively greater slope, and ordinarily pursues its upward course with more evenness. The irregularities of these two curves are wholly dependent upon the intricate specialties of particular trades and individual management. In some cases a general upward curvature may be observable; in others the average curvature may be concave on the lower side of the line. No simple mathematical formula could follow them accurately in any single case. It is, moreover, the purpose of the present paper to state fundamental general laws applicable to all trades, and for this purpose the perturbing influences of particular characteristics must be eliminated. Such elimination alone enables one to recognise the the broad tendencies that govern all trade growth, and this only can be useful in a general purview of the subject. Suppressing these perturbations, Fig. 2 is obtained, in which two straight lines are substituted for the irregular curves.

The horizontal ordinates are gross revenue, represented by the letter R. At 45 degs. to each axis is drawn a straight line, the height of which, therefore, also represents R, the vertical and horizontal scales being supposed equal. If for convenience the vertical scale is made

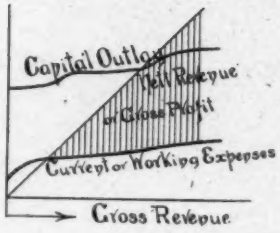


FIG. 1.

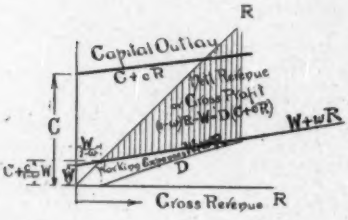


FIG. 2.

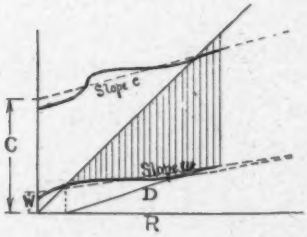


FIG. 3.

closer than the horizontal, this line must be drawn at a proportionately smaller slope, so that its height reads 1 on the vertical scale at unit horizontal distance.

The upper sloping line, representing gradually increasing capital outlay, starts at a height named C; and the tangent of its slope is named c, so that at any horizontal distance R its height is $C + cR$.

The lower line of current or working expenses starts at a height called W; the tangent of its slope is called w. Thus at the horizontal distance R its height is $W + wR$.

The height of the sloping R line over the $W + wR$ line gives the excess of gross revenue over working expenses, or the nett revenue. This is indicated on Figs. 1, 2 and 3 by the area rafined over vertically.

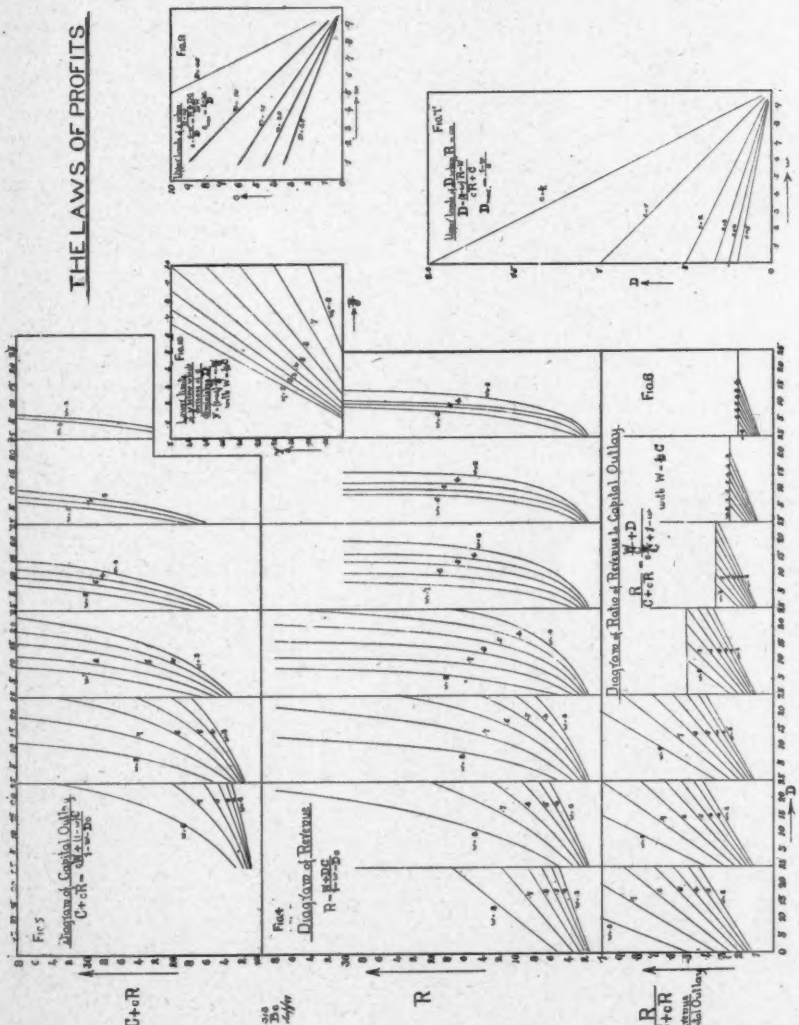
It will be noted that no nett revenue is cleared until the gross revenue has become larger than $\frac{W}{1-w}$, and the capital outlay become $C + \frac{c}{1-w} W$.

Beyond this point the nett revenue increases at a uniform rate. Its algebraic measure is $\{(1-w)R - W\}$.

The letter D here symbolises the ratio of nett revenue to capital outlay; that is, $D(C + cR) = (1-w)R - W$.

In Fig. 2 this ratio D is plotted off as the height of a curve. It starts at zero height at the gross revenue $\frac{W}{1-w}$, increases rapidly at first and then more and more slowly, rising asymptotically towards the limit $\frac{1-w}{c}$, which it never reaches. The excess of gross revenue over working expenses may, in accordance with the definitions adopted below, be termed indifferently nett revenue or gross profit. It represents the total annual remuneration to capital for both use and wear and tear; that is, it includes all the charges that are best represented as percentages of capital.

As already said, no particular case will give a diagram of exactly straight lines as in Fig. 2. Nevertheless, the construction here given is adapted to give the best available estimate of the future growth of the business through a short period, however widely its past history has deviated from the straight-line growth. Fig. 3 shows this adaptation. Here the full irregularly curved lines give the accurate plotting of the actual past history. The dotted lines are "up-to-date" tangents to these curves. They are produced backwards to cut the vertical axis of the diagram. The heights of their intersections on this axis are to be measured and used as C and W in the formulas; while their slopes, as measured from the diagram, are to be inserted in the formulas as c and w. The first part of the D curve is obtained from the actual Capital and Working Costs



FIGS. 4, 5, 6, 7, 8, AND 10.

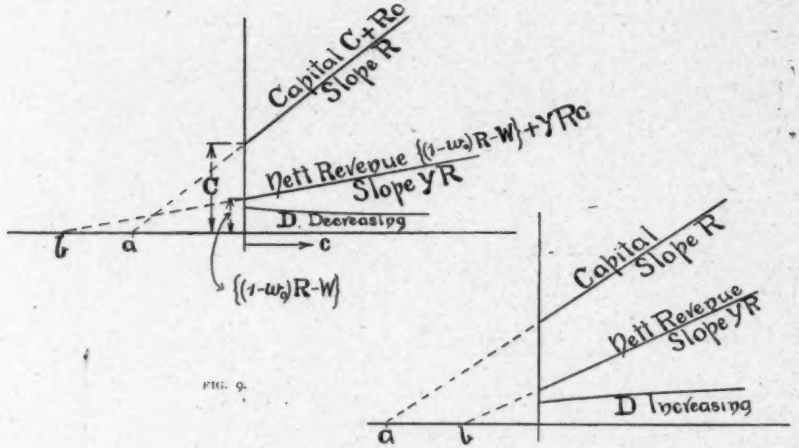


FIG. 9.

curves; its dotted continuation from the dotted tangents. For an estimate of the results likely to be attained at a distant future date a calculation of the average curvature of the lines, or the increment of their gradient, could no doubt be often made with considerable certainty, as is usually done in the case of large questions dependent on the growth of population; such, for instance, as the business of water or gas supply to a large town.

We divide the gross revenue R into two categories. The first provides the repayment of working expenses, or direct current cost of production. The other provides for the insurance and remuneration of capital.

To be specific, there may be here stated

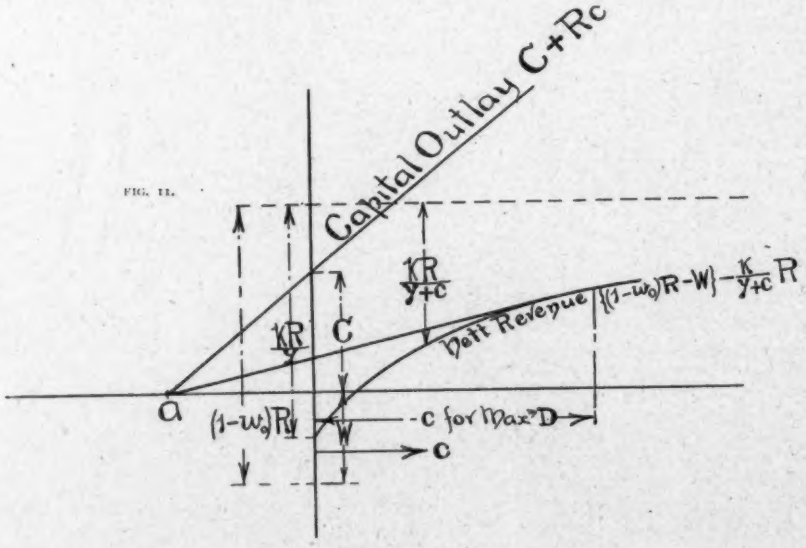


FIG. 11.

what is intended to be included and what excluded from "Working Expenses." Annual working expenses, or $W + wR$ INCLUDE costs of materials, power, wages, salaries, rent, rates, light, water, warming, office expenses, auditing, advertisement, ordinary repairs, legal expenses, special reserve funds for intermittent repairs, directors' fees, agency expenses and commissions; but EXCLUDE income tax, depreciation, insurance, general reserve funds, sinking fund, interest on debentures and mortgages, dividends on preference and ordinary shares.

These latter are in what follows bulked together in the expression $D(C + cR) = (1 - w)R - W$.

The nett remuneration for the use of capital includes, of course, interest on borrowed money and both preference and ordinary share dividends. If d be the average percentage of all these to the total capital employed, and i be the interest paid on borrowed money, then when

Borrowed Capital / Total Capital	equals	Av. Pref. and Ord. Share Dividend equals
$\frac{1}{3}$		$\frac{1}{2}(3d - i)$
$\frac{2}{3}$		$\frac{1}{5}(8d - 3i)$
$\frac{4}{10}$		$\frac{1}{6}(10d - 4i)$
$\frac{1}{r}$		$\frac{1}{r-1}(rd - i)$

The straight line law explained above gives very simply the following six equations. These are merely different expressions of one law; they are convenient transformations, showing how that law specially affects each of the six quantities that are of importance. One of these, namely the ratio of gross revenue to total capital outlay, or $\frac{R}{C + cR}$ is shortly named ρ. The symbol D_m represents the limit towards which D advances asymptotically as R becomes extremely large.

Gross Revenue :—

$$(1.)\quad R = \frac{W + DC}{1 - w - Dc} = \frac{1}{c} \cdot \frac{W + DC}{D_m - D}$$

Total Capital Outlay :—

$$(2.)\quad C + cR = \frac{cW + (1 - w)C}{1 - w - Dc} = \frac{W + D_m C}{D_m - D}$$

Ratio of Revenue to Capital :—

$$(3.)\quad \rho = \frac{R}{C + cR} = \frac{\frac{W}{C} + D}{c\frac{W}{C} + 1 - w} = \frac{1}{c} \cdot \frac{\frac{W}{C} + D}{\frac{W}{C} + D_m}$$

Ratio of Gross Profit to Capital :—

$$(4.)\quad D = \frac{(1 - w)R - W}{C + cR} = \rho\left(1 - w + c\frac{W}{C}\right) - \frac{W}{C}$$

$$D_m = \frac{1 - w}{c}$$

Ratio of *Extra* Working Costs to *Extra* Revenue :—

$$(5.)\quad w = 1 - Dc - \frac{W + DC}{R} = 1 + c\frac{W}{C} - \frac{1}{\rho}\left(\frac{W}{C} + D\right)$$

$$w = 1 - cD_m$$

Ratio of *Extra* Capital Outlay to *Extra* Revenue :—

$$(6.)\quad c = \frac{1 - w}{D} - \frac{W + DC}{DR} = \frac{1}{\rho} - \frac{C}{W}\left(1 - w - \frac{D}{\rho}\right)$$

$$c = \frac{1 - w}{D_m}$$

Equation (1) shows what revenue must be attained before a given ratio D of gross profit to capital can be reaped under the conditions defined by C c W w. The second form of the equation shows how hugely R must be developed before D can be pushed to near equality with the maximum possible D_m, this form showing that R is inversely proportional to the difference $(D_m - D)$.

Fig. 4 gives this law in diagram form. It is divided into seven sections corresponding to seven values of c, the lowest being 0—that is, no capital outlay incurred beyond the initial outlay—and the highest 5, which means that for every increase of £1,000 in the gross annual revenue a new capital outlay of £5,000 is involved. In each section the horizontal ordinate is D, running from 0 to 25 per cent. In each section appear seven curves, each corresponding to a given value of w, that for the lowest curve being $\frac{5}{10}$ and that for the highest $\frac{8}{10}$. In section 1 for $c = 0$, all the curves become straight lines. Throughout this diagram C is assumed as 10 while W is taken as 1; it does not matter whether the units be considered pounds, or £1,000, or dollars, or francs, or millions of francs.

It will be noted that the curves soon turn up very steeply, giving practically impossible R's considerably before the limiting D_m is reached. As this D_m is inversely proportional to c, this makes several of the curves fall wholly outside the limits of the diagram sections lying near the right hand end of the series.

The lower end of each curve runs down to zero D, while R is still $\frac{W}{1-w}$, or in this case $\frac{1}{1-w}$.

Fig. 5 illustrates equation (2), the similar growth of capital outlay. Here again the diagram is scaled for $C = 10$ and $W = 1$, and is divided into the same sections for the same values of c. The curves have the same general trend as the R curves, but do not bend upwards so rapidly. Again several of them for the larger c's and larger w's disappear altogether outside the limits of the diagram, indicating impracticably large capital outlays for these conditions. Independently of the impracticably great outlay required, it may be seen that even the maximum possible D's become so small that, seeing D includes many capital charges besides dividend, no dividend is really possible.

The lower ends of these curves run to zero D, while the capital outlay is still equal to $\frac{c}{1-w} W + C$; or in this case,

$$\left(\frac{c}{1-w} + 10\right) = \left(\frac{1}{D_m} + 10\right).$$

In Fig. 6 appears the diagrammatic form of the third law, showing the relation between D and the very important ratio ρ of revenue to capital. A glance at equation (3) proves that the co-ordination of ρ and D gives a series of straight line diagrams, which are therefore very easily drawn. The simplest procedure is first to calculate $D_m = \frac{1-w}{c}$; then at $D = 0$ to plot $\rho = \frac{1}{c\left(1 + \frac{C}{W} D_m\right)}$ and at $D = D_m$ to plot $\rho = \frac{1}{c}$. Between these two points the straight line is drawn. It has no existence beyond the latter point, D being incapable of going above D_m, and therefore ρ incapable of going higher than $\frac{1}{c}$. In each section of this Fig. 6, the sloping lines are cut off at this limit $\frac{1}{c}$. In this figure the ratio $\frac{W}{C}$ is assumed as $\frac{1}{10}$, but no special values are assigned to either W or C.

This diagram makes very clear that small ratios ρ cut out many of the larger values of w and c as impracticable under the condition that D is to be large enough to yield a dividend. It also shows that large c's make profit-making conditions specially difficult of attainment. The large c restricts the growth of ρ within low limits, while within these limits it requires a very low value of w to pull D up to such a figure as will leave any surplus over the preliminary and non-profit yielding charges upon capital.

The ratio ρ varies immensely. In ship-

building it has been 175 per cent., and in textile manufactures 150 per cent. At the other end of the scale, gas companies on the average reap no more than 25 per cent. of their capital in yearly gross revenue; electric lighting undertakings 10 to 15 per cent.; British railways on the whole only 10, and water companies still less.

As D is taken as horizontal ordinate in all these diagrams, equation (4) giving D in terms of the other quantities, is illustrated fully by the whole set of them.

The above remarks demonstate the ruling importance of the two ratios w and c in the genesis of genuine profit. In the previous diagrams it is seen how the lines for large w's lie above and to the left of those for small w's, thus rendering the attainment of any but low values of D difficult. Attention is commonly directed to the ratio of total working costs to revenue, namely, the ratio

$$(W + wR) \div R = W/R + w,$$

this being obtained from the accounts much more easily than the vastly more important ratio w. Again, the ratio of total working costs to total capital, *i.e.*, $(W + wR) \div (C + cR)$ is of much less importance than the ratio w/c. That is, the ratios between the total quantities capital, revenue, and working costs are of inferior importance to that of the ratios between their simultaneous rates of increase or growth.

The effects of w and c are, perhaps, most plainly exhibited by considering their very simple connection with D_m, the asymptotic limit towards which D rises as R becomes very large. This relation is—

$$D_m = \frac{1 - w}{c}, \text{ or } c = \frac{1 - w}{D_m}, \text{ or } w = 1 - c\,D_m.$$

This relation is exhibited in the straight-line diagrams Figs. 7 and 8. In both these the base ordinates are w. In Fig. 7 a series of straight lines correspond to different c's, and the height of each read from the vertical scale gives the varying value of D_m, as w ranges between the limits 0 and 1. All these lines radiate from the right-hand lower corner of the diagram, because when $w = 1$, then $D_m = 0$. Again, at the left-hand edge the height of each line is $\frac{1}{c}$, this being the value of D_m when $w = 0$. Between each such pair of points a straight line is drawn. The lines for the large c's lie, of course, low down in the diagram. Thus a desired D_m may be obtained by combining a small c with a large w, or a large c with a small w. If either w or c be increased separately without change of the other, the effect is to diminish D_m.

In Fig. 8 the vertical heights measure c, each oblique line corresponding to one value of D_m: the values of D_m chosen being 5, 10, 15, 20, and 25 per cent. Here again all the lines radiate from the lower right-hand corner, because when $c = 0$, then $w = 1$. When $w = 0$, then $c = \frac{1}{D_m}$, and this gives the height at the left-hand edge of the diagram. This diagram shows even more clearly than the last that the product of $c\,w$ must be kept low in order to get a large D.

It should be noted that this relation between D_m, w and c is not influenced by either C or W or by the ratio W/C.

The equations (5) and (6) are best illustrated by numerical examples:—

Suppose that with $C = £10{,}000$ and $W = £1{,}000$, it is proposed that extra capital outlay to the extent of £1,500 should be permitted for every extra £1,000 reached by the revenue (*i.e.* $c = 1\frac{1}{2}$), and that it is desired that D should rise to 25 per cent. when the revenue has reached £20,000. To attain this result, the increase of working costs must by equation (5) be kept down to

$$w = 1 - 1\tfrac{1}{2} \times \cdot 25 - \frac{1000 + 2500}{20000} = \cdot 45,$$

which would make the working costs £10,000 per annum when the reveue is £20,000, or 50 per cent. of the revenue. Note the difference between this 50 per cent. and $w = 45$ per cent. The gross profit is now 20,000 − 10,000 = £10,000 and the capital outlay 10,000 + $1\frac{1}{2}$ × 20,000 = £40,000, of which £10,000 is the desired 25 per cent.

Again suppose that with $C = £10{,}000$ and $W = £1{,}000$, it is known that extra

revenue will involve spending 60 per cent. of the increased receipts in increased working costs: *i.e.*, $w = \cdot 6$. Then to reach a $D = 20$ per cent. when the revenue has mounted to £15,000, or $DR = £3{,}000$, equation (6) indicates that increase of capital outlay must be be restricted to

$$c = \frac{1 - \cdot 6}{\cdot 2} - \frac{1000 + 2000}{3000} = 2 - 1 = 1,$$

so that when $R = £15{,}000$, the total capital outlay would be £25,000, while the working costs would be $1{,}000 + \cdot 6 \times 15{,}000 = £10{,}000$. The gross profit would thus be £15,000 − £10,000 = £5,000, which is the desired 20 per cent. of £25,000.

The most common motive for expending further capital is to attract, and provide the means of earning, additional revenue. But another motive is also often operative, namely, to diminish working expenses by introducing better appliances and better organisation. Honest and skilful expenditure on capital account nearly always effects a saving in working costs; additional saving, however, becoming more and more difficult, the more liberal has been the previous skilfully-directed capital outlay. The problem, therefore, always arises to what extent this process of saving on working costs by more liberal capital outlay should be carried. Given a reciprocal relation between c and w, what corresponding values of c and w will yield the largest D?

The simplest mathematical expression for this reciprocal relation is

$$(7.) \qquad w = w_o - y\,c,$$

where w_o and y remain constant while w and c vary. Here w_o is a comparatively large fraction and y a small one—smaller for small w_o than for large w_o. An example is $w_o = \cdot 65$ and $y = \cdot 05$, giving

c	0	½	1	2	3	4	5
w	·65	·625	·60	·55	·50	·45	·40

Putting this expression for w in equation (4) there is obtained

$$(8.) \quad D = \frac{(1 - w_o)\,R - W + y\,R\,c}{C + c\,R}.$$

When the differential co-efficient of this with respect to c is equated to zero, the ordinary method of finding the value of c giving maximum D, it is found that c cancels out of the expression, thus giving no maximum D. This means that D either increases or diminishes with increase of c, whatever c may be, and according to the values of the other quantities involved.

Fig. 9 explains the condition very simply. Here the base ordinates are c; the upper straight line shows how $(C + cR)$ increases with c for a given constant R. The lower line shows how $\{(1 - w_o)\,R \div W + y\,R\,c\}$ increases with c. The slopes of the two lines are R and $y\,R$, the ratio between these being $1/y$. The lines produced backwards cut the base at the points marked a and b. If b coincided with a, the ratio between the heights of the two lines, which is D, would remain the same for all c's. If, as in the first part of Fig. 9, b lies to left-hand of a, D falls if c be increased. If b lies to right of a, as in the second part of Fig. 9, D will rise as c is increased, and will do so without limit so long as y is unaltered. Actually y cannot remain unchanged for any very large range of c—if it remained constant, an increase of c to $\frac{w_o}{y}$ would reduce w to 0, which is always impossible. Nevertheless, this rule is the most useful that can be applied to this problem, because it is never or seldom desired to judge of the effect of any sweeping and revolutionary changes; changes are, or should be usually, carried out step by step, and for each successive step the proper value of y may be safely estimated. In fact, mathematicians will readily recognise that, assuming any complicated law connecting w and c, the $-y$ of the above equation is at each point of the curve simply the differential coefficient of w with respect to c, which can be quite properly used as a safe guide in estimating any short advance along the curve. This being understood, it is useful to write down the condition in algebraic form, the meaning being identical with that already explained geometrically by Fig. 9. It may be stated as a limiting value of y, or of R. Thus

(9.) D is increased by increasing c

$$\text{if } y > \frac{(1 - w_o)\,R - W}{C},$$

$$\text{or if } R < \frac{y\,C + W}{1 - w_o},$$

$$\text{or } \frac{R}{C} < \frac{y + \frac{W}{C}}{1 - w_o},$$

If y or R fall on the other sides of these limits, D is decreased by increasing c. Thus, so long as R is small, a relatively small value of y will make increase of c profitable, but when R has increased beyond a certain limit the same value of y would make it profitable to contract new capital expenditure.

In Fig. 10 is given very full illustration of these limits. In this the ratio $\frac{W}{C}$ is taken as $\frac{1}{10}$, and the ratio $\frac{R}{C}$ is taken as the horizontal ordinate in the diagram. A series of eight straight lines is drawn corresponding to eight values of the fraction w_o. The vertical heights of these lines measure the y at the limit between increase and decrease of D with increase of c, the scale for y ranging from 0 to $\frac{1}{2}$. The diagram may be used for reading off y for given w_o and $\frac{R}{C}$, or for reading $\frac{R}{C}$ for given w_o and y.

Another formula for the reciprocal relation between w and y is

$$(10.) \qquad w = w_o + \frac{k}{y + c}.$$

An illustration of this law is here given, namely, for

$$w_o = \cdot 5\,;\ k = 1\,;\ y = 4.$$

These values give for

$c =$	0	$\frac{1}{2}$	1	2	3	4	5
$w =$	·75	·72	·70	·67	·64	·625	·61

This may be applied to a longer range of variation of c than can equation (7). Using this in equation (4) we obtain

$$(11.) \qquad D = \frac{(1 - w_o) R - W - \frac{k}{y + c} R.}{C + R c}$$

If the differential coefficient of this with respect to c be equated to zero, it shows a maximum value of D reached when c is given the value in (12) below or R reaches that in (13).

$$(12.) \qquad c = \frac{k R}{(1 - w_o) R + W} \left\{ 1 + \sqrt{\frac{(C - y R) \{ (1 - w_o) R + W \}}{k R^2}} \right\} - y.$$

$$(13.) \qquad R = \frac{k C - (y + c)^2 W}{k (y + 2c) - (1 - w_o) (y + c)^2}$$

These being complicated expressions, the graphic solution given in Fig. (11) is preferable. Here the line $(C + Rc)$ is drawn and produced backwards to cut the base in the point a. The curve $\left\{ (1 - w_o) R - W - \frac{k}{y + c} R \right\}$ is also drawn, and to this curve is drawn a tangent from the point a. The touching point between this tangent and the curve gives the value of c which ensures the greatest possible D.

These problems of maximum economy have sometimes been attacked from the point of view of finding the maximum possible total profit without reference to the amount of capital used. Lord Kelvin's calculation of the most profitable current density to employ in electric power transmission was an early instance of this, and later the present author made similar calculations of the most economic size of pipe to use in hydraulic transmission of power, and of the most economic cut-off in steam engine cylinders having regard to the initial cost of large and small cylinders. But these solutions seem to imply that it is a matter of indifference to the undertakers how much or how little capital is employed, it being assumed that there is available an unlimited supply of capital on which a fixed interest per cent. is to be paid. But the borrowed capital in limited liability concerns cannot exceed from $\frac{1}{2}$ to at most $\frac{2}{3}$ of the subscribed share capital. Whatever proportion it may take, the main aim of the proprietors must always be to make the whole gross profit, including interest on borrowed money, bear as great a ratio as possible to the whole capital employed. That is, this aim is to bring D to a maximum, which is a very different thing from bringing $D\ (C + c R)$ to a maximum. In the latter part of this paper the author has endeavoured to formulate two rules guiding in this direction.

Robert A. Smith

Testing the Magnetic Qualities of Materials in Bulk.

By C. V. DRYSDALE. D.Sc.

DURING a recent session of the Institution of Electrical Engineers a Permeability Bridge, by Messrs. Lamb & Walker, was introduced, and in the discussion which followed Messrs. Evershed, Esson, and Hammond drew the attention of the audience to the want which was felt by manufacturers of an instrument which would enable them to determine the magnetic quality of any casting or forging before a large amount of time and expense had been spent in machining it.

If such castings or forgings could be tested and accepted or rejected immediately on delivery, a much greater certainty in the design of machines might be attained.

Hitherto the numerous instruments that have been devised for the testing of the magnetic quality of material have all been open to the objection that, from the point of view of the electrical engineer, specially prepared specimens — usually in the shape of rods of some inches in length, which have to be accurately turned and perhaps faced — have been necessary. Not only is the preparation of these specimens troublesome, but it is very rarely that tests made on them are of practical value, as they cannot be prepared from the bulk of a casting or forging.

Again, the different specimens of iron, however carefully prepared, may show considerable differences in their magnetic qualities.

The importance of the subject of testing in bulk, and of the references made by Messrs. Evershed, Esson, and Hammond at the meeting referred to, so impressed the author of this paper, that he set to work immediately afterwards to devise a piece of apparatus with which permeability tests could be made directly on the castings or forgings. The following text, which is substantially reproduced from the paper read before the same Institution, describes in detail the apparatus and various tests made with it. Some of the latter were repeated at the meeting, and served to demonstrate the complete success and utility of the permeameter.

A permeameter for commercially testing iron or steel for engineering purposes should, as far as possible, fulfil the following requirements :—

(*a*) It should be capable of testing specimens, either in the form of large or small castings or forgings, or in the form of rods or plates.

(*b*) The test should be rapidly effected.

(*c*) The apparatus should be self-contained and portable.

(*d*) The instruments should be direct reading, and the test should not require experimental skill.

(*e*) It should be capable of testing either the permeability, the retentivity, or the complete hysteresis cycle.

(*f*) It should be simple and strongly made, and should be capable of being easily checked or recalibrated if deranged. It should *not* depend on previously standardised specimens.

The above list contains practically all the most important points, and it will be seen from what follows, how far the apparatus satisfies these requirements.

A few preliminary remarks on the principles which led to the design of the instrument may not be out of place, as they may lead to other solutions of the problem.

The various methods of testing the permeability of iron may be divided into three principal classes.

I. *Magnetometer methods.* In these the specimen is usually in the form of a long thin rod, and its magnetisation is measured by the external force it produces at some point.

II. *Ring methods*, in which the specimen is made up into a complete or split ring, the magnetisation being measured by search coil or by the attraction between the two halves of the ring.

III. *Yoke methods.* The specimen is here in the form of a uniform rod, and is provided with a heavy iron yoke or return path. Numerous devices are employed to determine the magnetisation.

At first sight one would look for some form of magnetometer test as being the most promising, but the difficulty is, first, that in irregularly-shaped bodies the connection between the external forces and the intensity of magnetisation cannot easily be arrived at; and, secondly, that unless the specimen is very long in comparison with its transverse dimensions, its quality has very little effect on the field produced. It does not seem likely that any universal method can be devised which depends upon this principle.

The objection to either of the latter methods, from a practical point of view, is that if the ring or bar is of any great size, it cannot be prepared from the casting or forging. If, however, it can be arranged to use very small rings or rods, there is no reason why they should not be drilled from the bulk of the metal to be tested. The rods could be drilled out by some form of hollow drill, while the rings could be easily cut out of the solid by a properly designed expanding drill.

The ring method, however, suffers from the further objection that the magnetising and search coils have to be wound through the centre of the ring, which would be exceedingly troublesome. Moreover, it would be somewhat difficult to ensure the exact dimensions of the ring. We are thus thrown on the yoke method, and this may be carried out by drilling out a straight cylindrical specimen from the bulk, and inserting it in a yoke as in a Hopkinson permeameter.

The writer has adopted the plan in commercial testing of making both the specimen and the greater part of the return path from the bulk of the material tested. A drill of a special form is

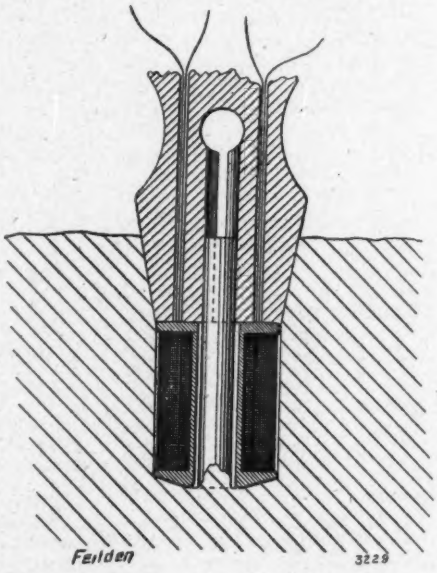


FIG. 1.—SECTION THROUGH PLUG AND SPECIMEN.

employed, which cuts a circular hole in the specimen, conical at the top, leaving a pin in centre of it. In the instrument usually made this hole is $\frac{3}{8}$ in. in diameter and $\frac{1}{2}$ in. deep, and the diameter of the pin is $\frac{1}{10}$ in., but these dimensions could be considerably reduced if necessary.

The testing arrangement consists simply of a soft iron plug, carrying a bobbin, on which are wound two circuits, a magnetising coil and a search coil. The plug is split, and is turned slightly conical on its outside surface, while the drill cuts the cone of

the same angle as that of the plug. It will thus be seen (Fig. 1) that on drilling the hole and inserting the plug a perfect miniature permeameter is produced, having an exceedingly good magnetic circuit, and in which either the permeability, retentivity, or hysteresis can be determined by ordinary methods.

Before going further into the details of the apparatus it will be well to say a few words about the drilling of the specimen. There are very few castings or forgings in which a hole of the size mentioned would not be admissible probably in the places reserved for bolt holes; but in the event of its not being allowable, there is no objection to a boss being left on the casting in any convenient position for the purpose of test, and which could be cut off before drilling. This is analogous to the procedure adopted in optical work, where for large telescopes the discs of glass are cast for small projections, from which the prisms can be cut for testing. For small castings, as above mentioned, it would be possible to reduce the drill and plug to half the dimensions above stated, if necessary. The time of drilling appears to be about ten minutes in the case of cast iron, and about fifteen minutes in the case of wrought iron; but this appears to be a small consideration in comparison with the importance of the information obtained, and it may be possible to reduce this time considerably.

Fig. 2 shows the connections which are most simply employed. The magnetising coil *MC* of the plug is supplied with current from a battery *B*, through a regulating resistance *R* and ammeter *G*, and reversing switch *RS*. Connection is also made from the search coil *SC* to a ballistic galvanometer G_2. On making, breaking, and reversing, the switch deflections are obtained on the galvanometer G_2, which are proportional to the magnetisation of the specimen.

In order to make the instruments direct reading, it is easy to provide a scale for the galvanometer G_1, so that it reads the value of *H*. In the same way a scale is provided for G_2 reading the values of *B* directly. The permeability is then obtained, if necessary, by dividing the value of *B* by that of *H*; but it is generally sufficient to compare the values of *B* obtained with the curve of some satisfactory specimen.

In ordinary commercial testing of castings, etc., it would probably be sufficient to know the value of the permeability for one value of the magetising force. In this case the arrangement may be further simplified by withdrawing the resistance *R* and galvanometer *G*, and simply arranging for the cells to give one definite current. The divisions on the galvanometer G_2 may then be marked directly with values of the permeability.

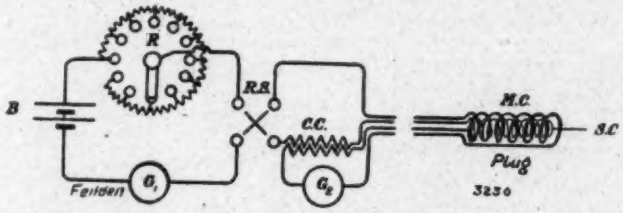


FIG. 2.—CONNECTIONS FOR BALLISTIC TEST.

There are, of course, other methods of taking the observations, and two of them will be mentioned here, as different engineers may prefer different methods.

Zero-reading Method.—The determination of the permeability of the iron of course simply resolves itself into the determination of the self-induction of the magnetising coil. Fig. 3 shows a very sensitive method of effecting this, in which the magnetising coil *MC* is connected in one arm of a bridge, and an Ayrton-Perry variable standard of self-induction in the

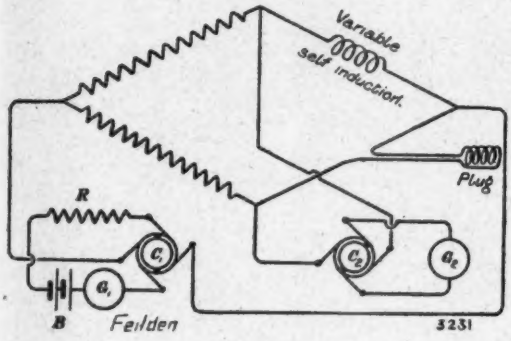


FIG. 3.—CONNECTIONS FOR ZERO TEST.

opposite arm. C_1 and C_2 are the two commutators of the secohmmeter, G_1 the galvanometer for measuring the values of H, while the galvanometer G_2 is simply a zero-reading instrument. The reading is then taken by rotating the secohmmeter and turning the inner coil of the variable self-induction standard till balance is obtained. The reading of this instrument can be made to give the permeability direct, while that of G_1 gives the value of H. The galvanometer G_1 must, of course, be calibrated with due regard to the fact that the current divides in the two halves of the bridge, and that the current is periodically interrupted by the secohmmeter. Where an alternating supply is available, the secohmmeter may be dispensed with, and a telephone substituted for G_2. The alternating current might be supplied by a portable generator.

Direct Deflection Method.—For those who prefer to simply turn a handle and grind out a direct reading, which is apparently the highest ideal in an engineer's instrument, the connections may be made as in Fig. 4. In this case a secohmmeter is again used, but it is connected so that one commutator reverses the magnetising circuit while the other reverses the search coils circuit. The magnetising and search coils are each connected with one of the coils of an ohmmeter, and a magnetic needle will then give a reading depending on the ratio of B to H, or the permeability direct, while the values of H and B are separately given by the galvanometers G_1 and G_2. This method, like the last, has the advantage that only one winding is necessary in the plug; it makes, in fact, a simple universal method of measuring both resistance and self and mutual induction. Provision must, of course, be made in this test for running the secohmmeter at a definite speed. This might also be possibly employed with an alternating current of definite frequency by removing the secohmmeter and substituting a soft-iron iron needle in the ohmmeter.

COMMERCIAL FORMS OF THE APPARATUS.

Notwithstanding the attractions which the two latter methods offer, I have preferred, up to the present, to adhere to the simple ballistic test, as it requires only slightly more skill to read the ballistic throw, and the connections are more simple. Moreover, the handle-turning methods do not lend themselves well to determining the retentivity of the

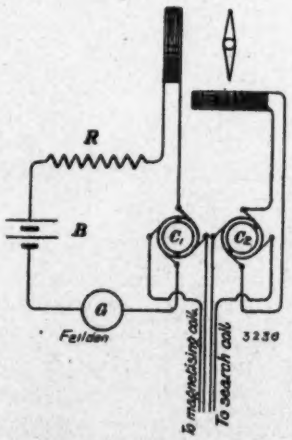


FIG. 4.—CONNECTIONS FOR DIRECT DEFLECTION TEST.

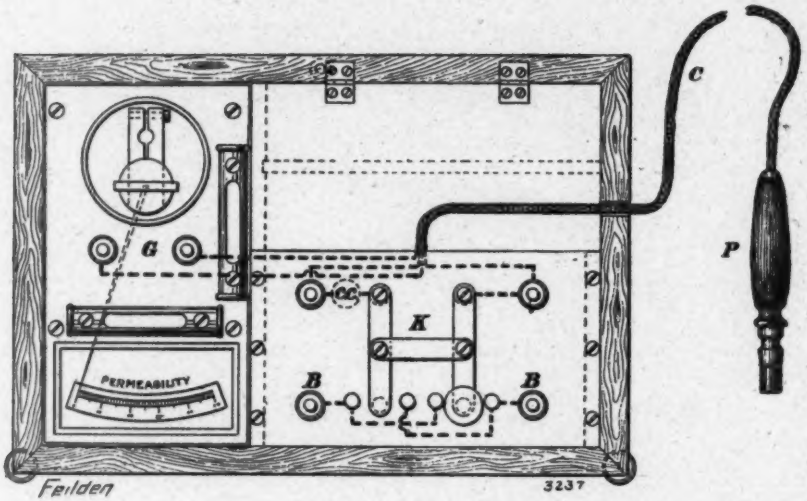


FIG. 5.—PERMEABILITY TESTING SET.

specimens or their B-H cycles, but simply give the mean B-H curve.

The apparatus is at present made in two forms—the simplex, which allows of the permeability and retentivity being directly read off, and the second, in which the magnetisation curve and the B-H cycle can also be arranged.

Fig. 5 shows the former of these arrangements. It simply consists of a wooden case, 11 by $7\frac{1}{2}$ by $11\frac{1}{2}$ in. high, containing a battery of two large dry cells, a reversing key K, the plug P which is connected by a long quadruple flexible conductor C to the key K, and to a d'Arsonval ballistic galvanometer G, which is marked directly in values of the permeability. Space is provided under a flap for the plug and drills.

In order to obtain a test, all that is necessary is to drill the specimen, insert the plug and reverse the key. The pointer then swings to the value of the permeability, and if the circuit is then broken and twice the second reading taken from the first, the value of the retentivity is given.

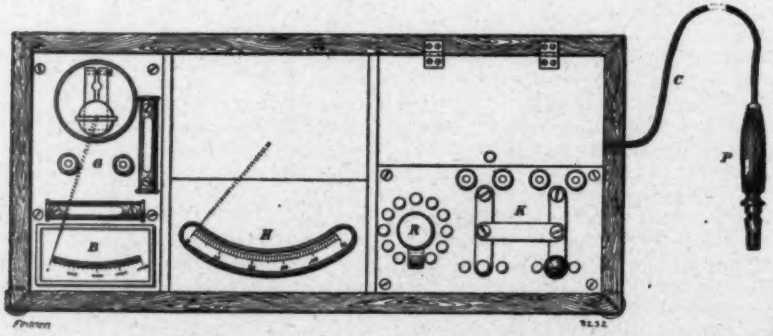


FIG. 6.—COMPLETE SET FOR PERMEABILITY AND MAGNETISATION TEST.

In Fig. 6 the complete set is shown, which differs from the last only in the addition of the milliammeter B and the resistance dial R, increasing the length of the case to 16½ ins. The galvanometer G is then arranged to read the values of B and also the values of μ when $H = 100$. The total and residual magnetisation curves are obtained as before, while the cycles are determined by observing the throws corresponding to successive variations of the resistance and summing them in the well-known manner. Fig. 7 shows total and residual magnetisation curves for three specimens of mild steel, wrought iron, and cast iron, while Figs. 8 and 9 represent the corresponding B-H cycles obtained in this way from two of the specimens. The annexed tables contain the readings actually obtained :—

TABLE I.

TESTS OF MAGNETISATION AND RETENTIVITY OF MILD STEEL SPECIMEN.

H.	B.	Deflection on Break.	Residual Magnetisation.
5	3,600	750	2,100
7·5	5,700	1,200	3,300
13·5	8,900	1,900	5,100
22	11,400	2,700	6,000
35	13,500	3,400	6,700
44	14,600	3,800	7,000
58·7	15,400	4,100	7,200
76·5	16,200	4,500	7,200
98·2	16,850	4,800	7,300
140	17,600	5,100	7,300
188·5	18,400	5,400	7,600

TABLE II.

TESTS OF MAGNETISATION AND RETENTIVITY OF WROUGHT IRON SPECIMEN.

H.	B.	Deflection on Break.	Residual Magnetisation.
5·2	1,800	340	1,120
7·5	3,300	600	2,100
13·6	6,370	1,330	3,710
19·7	8,600	1,850	4,900
35·3	11,400	2,800	5,800
44	12,400	3,200	6,000
59	13,300	3,600	6,100
80	14,200	3,900	6,400
101	14,700	4,200	6,300
132·4	15,350	4,400	6,550
183·5	16,000	4,700	6,600

TABLE III.

TESTS OF MAGNETISATION AND RETENTIVITY OF CAST IRON SPECIMEN.

H.	B.	Deflection on Break.	Residual Magnetisation.
2·0	150·0	90	...
3·7	260·0	120	20
7·0	520·0	200	120
10·2	900	280	340
18·4	2,100	520	1,060
33·5	3,900	900	2,100
59·2	5,450	1,200	3,050
77·5	6,150	1,470	3,210
100·5	7,000	1,800	3,400
123·8	7,400	2,000	3,400
148·0	7,800	2,050	3,700
217·5	8,750	2,500	3,750

TABLE IV.

MAGNETISATION CYCLE OF MILD STEEL SPECIMEN.

H	D	B=ΣD
+ 34	+ 13,070	+ 13,070
+ 22	− 800	+ 12,270
+ 16	− 750	+ 11,520
+ 13·5	− 450	+ 11,070
+ 7	− 1,400	+ 9,670
+ 3	− 1,500	+ 8,170
0	− 1,750	+ 6,420
− 3	− 4,150	+ 2,270
− 5	− 3,400	− 1,130
− 7	− 2,800	− 3,930
− 13	− 4,300	− 8,230
− 17·5	− 1,600	− 9,830
− 21·8	− 1,100	− 10,930
− 28·7	− 1,350	− 12,280
− 33·7	680	− 12,960
− 22	+ 800	− 12,160
− 16	+ 800	− 11,360
− 13·5	+ 400	− 10,960
− 7·5	+ 1,500	− 9,460
− 2	+ 1,900	− 7,560
0	+ 1,700	− 5,860
+ 2	+ 3,800	− 2,060
+ 3·8	+ 2,300	+ 240
+ 7·5	+ 4,400	+ 4,640
+ 13	+ 4,000	+ 8,604
+ 17	+ 1,500	+ 10,140
+ 25	+ 1,700	+ 11,840
+ 33	+ 1,300	+ 13,140

TABLE V.
MAGNETISATION CYCLE OF WROUGHT IRON SPECIMEN.

H.	D	B=ΣD
+ 34·5	+ 9,600	+ 9,600
+ 23·7	− 400	+ 9,200
+ 18	− 450	+ 8,750
+ 13	− 400	+ 8,350
+ 13	− 50	+ 8,300
+ 7	− 800	+ 7,500
+ 2·5	− 1,200	+ 6,300
+ 0	− 850	+ 5,450
− 2·5	− 1,500	+ 3,950
− 5	− 1,950	+ 2,000
− 7	− 1,880	+ 120
− 12·2	− 4,250	− 4,130
− 16·8	− 1,800	− 5,930
− 24	− 2,200	− 8,130
− 33·7	− 1,600	− 9,730
− 19·2	+ 700	− 9,030
− 15·2	+ 300	− 8,730
− 13	+ 300	− 8,430
− 7	+ 900	− 7,530
− 3·7	+ 800	− 6,730
0	+ 1,450	− 5,280
+ 3·5	+ 2,600	− 2,680
+ 5	+ 950	− 1,730
+ 7	+ 1,850	+ 120
+ 12·5	+ 3,600	+ 3,720
+ 16·5	+ 1,900	+ 5,620
+ 21	+ 1,400	+ 7,020
+ 28	+ 1,400	+ 8,420
+ 34·5	+ 950	+ 9,370

TABLE VI.
MAGNETISATION CYCLE OF CAST IRON SPECIMEN.

H.	D	B=ΣD
+ 35·7	+ 4,300	+ 4,300
+ 25·5	− 400	+ 3,900
+ 19·6	− 220	+ 3,680
+ 5·5	− 800	+ 2,880
+ 3·0	− 230	+ 2,650
0	− 360	+ 2,290
− 3·0	− 380	+ 1,910
− 4·5	− 350	+ 1,560
− 7·0	− 650	+ 910
− 18·0	− 3,150	− 2,240
− 23·2	− 870	− 3,110
− 31·8	− 980	− 4,090
− 34·3	− 320	− 4,410
− 23·8	+ 350	− 4,060
− 17·7	+ 320	− 3,740
− 5·3	+ 700	− 3,040
− 3·3	+ 220	− 2,820
0	+ 320	− 2,500
+ 3·2	+ 400	− 2,100
+ 5·4	+ 400	− 1,700
+ 9·8	+ 1,350	− 350
+ 16·6	+ 2,000	+ 1,650
+ 21·2	+ 880	+ 2,530
+ 26·0	+ 750	+ 3,280
+ 34·1	+ 720	+ 4,000

DETAILS OF CONSTRUCTION AND CALIBRATION.

It will be necessary to say a few words about the construction of some of the parts of the apparatus in order to show what amount of confidence may be placed in the results.

About the drills little need be said, except that they must all be made accurately to gauge, so as to be interchangeable. In order to make them more easy to centre truly in drilling they are now made with a certain amount of relief in the bottom cutting edges. The form used did not seem to be truly in conformity with the best principles as to cutting edges, and it is probable that improvements may be effected whereby the time of drilling may be considerably reduced. It is, however, the best of some two or three forms that have been tried.

The plug demands a little more attention. To make the magnetic joints as perfect as possible the plug is very carefully turned to have the same angle as the drill, and the central hole the same diameter as that of the pin. In order, however, to ensure perfect contact the plug is split longitudinally, as will be seen on looking back at Fig. 1, so that on pushing it into place it grips tightly on the pin. Great care is taken to have the bottom edge of the aperture in the plug quite sharp, so as to give certainty in the length of the pin used.

The magnetising and search coils are wound on an insulated brass bobbin split longitudinally to prevent eddy currents. This bobbin is screwed to the end of the plug in such a manner as to still allow of the yielding due to the slit, and the ends of the coils are brought up through the plug as shown.

In order to arrange for a perfectly definite length of specimen a standard piece of steel is kept which has been drilled in the ordinary manner and afterwards cut through near the edge of the cavity, so as to expose the interior. The plugs are then turned or ground down until, when they are pushed home in this specimen, the length of the pin exposed is exactly $\frac{1}{2}$ in. Since the value of H is $\frac{4\pi}{10}$ the ampère-turns per centimètre length,

the number of turns required for the current in milliampères to equal H in gauses is

$$\frac{10^6}{4\pi \times 39{\cdot}37 \times 2} = 1{,}010 \text{ turns.}$$

In calibrating the ballistic galvanometer it must not be forgotten that, being a moving coil instrument on a small external resistance, the damping is considerable—as, indeed, is necessary in a commercial instrument. Standardisation of the galvanometer by condenser is therefore unsatisfactory, and the best procedure is to obtain the throw corresponding to a known current and a known coefficient of mutual induction, or with a search coil and magnet previously measured on some other galvanometer.* If the search coil is of low resistance and is interposed in the galvanometer circuit the damping will be unaffected. Terminals are provided on the instrument which will allow of this test being made should it be necessary.

One other matter should not be forgotten. The small size of the pin makes the gap between it and the search coil of some influence on the results, as the coil not only cuts the lines passing through the pin, but those in the annular space between it and the search coil. The effect is not large, but it can easily be allowed for by the simple expedient of winding a few turns of wire in the magnetising and search-coil circuits together round a bobbin. A reading is first taken by reversing the current without the iron core. Then if D is this deflection, d_1 and d_2 the diameters of the pin and search coil, the deflection due to the space may be approximately taken as $\frac{d_2^2 - d_1^2}{d_2^2}$ D. The number of turns in the compensating coil is adjusted to give this deflection, in the opposite direction, and thus eliminates the effect entirely. The compensating coil is shown in Figs. 1 and 5 marked *C C*.

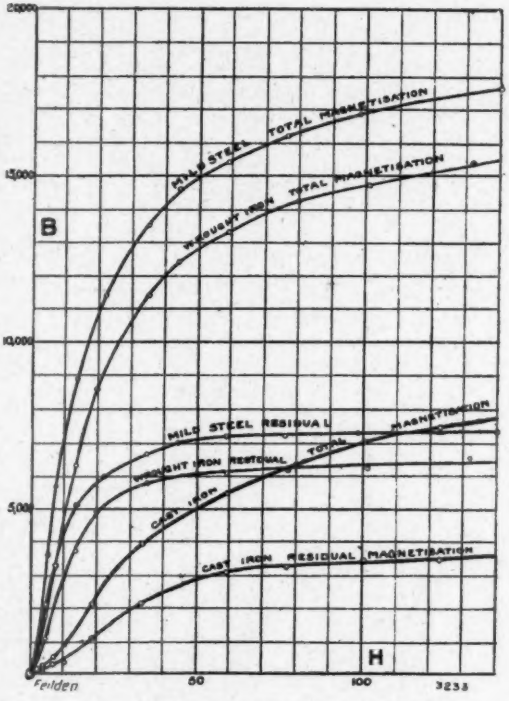


FIG. 7.—CURVES OF TOTAL AND RESIDUAL MAGNETISM.

The highest value of H employed is 100, which corresponds to 100 milliampères of current from the cells. As this is only on for the time of making and throwing over there should not be much trouble with deterioration of the cells.

A clamp is provided for fixing the coil of the galvanometer when not in use, and levelling screws are mounted in the base of the case.

ACCURACY OF THE METHOD.

The foregoing remarks will be quite sufficient to explain all the essential features of the instrument, and it now remains to see as to what reliance may be placed in the results obtained.

It was at first anticipated that owing to

* The Hibbert standard inductor may be conveniently employed.

the reduction of size of the specimen tested, such great accuracy could not be expected of this test as obtained with larger permeameters; but on examination the accuracy obtained was most satisfactory, so much so as to be quite equal to that of ordinary tests.

The first point to determine was of course whether the diameter and effective length of pin tested could be relied on with sufficient accuracy, and careful measurements were made on this point. The effective length of the specimen was determined by drilling out some holes with the specimen drill and afterwards cutting a longitudinal section of them near the edge. On inserting the plug the interior of the hole could then be seen, and the distance between the bottom of the plug and the end of the pin could be accurately measured with a reading microscope. These measurements were repeated several times, removing and re-inserting the plug between each set of readings, and it was found that the greatest variation from the mean did not exceed ·0008 of an inch, which in a length of half an inch means a variation of less than ·2 per cent. In the same way several pins were broken out of the holes after being drilled; and the greatest variation of the diameter was found to be less than half a mil, or of less than 1 per cent. of the area of section.

It will be seen from the above that the results may be relied on to within 1 per cent., as far as the dimensions are concerned. As before mentioned, special care has been taken in the construction of the split plug that the most perfect magnetic contact is made exactly at the point where the pin enters the plug, as otherwise the effective length might be greater than that measured.

The readings appear to reproduce themselves with the most perfect accuracy. In a deflection of 230 divisions, obtained with a certain value of the current in a cast iron specimen, a variation of one division in the deflection was very rare, although the plug was taken out and reinserted between the readings, and no particular care was used in replacing it. The perfection of the magnetic joint obtained by the conical fit appears to be all that can be desired, and is certainly better than can be obtained by any ordinary faced joints.

Some fear was at first felt that the great disproportion between the sizes of the specimen and return path might lead

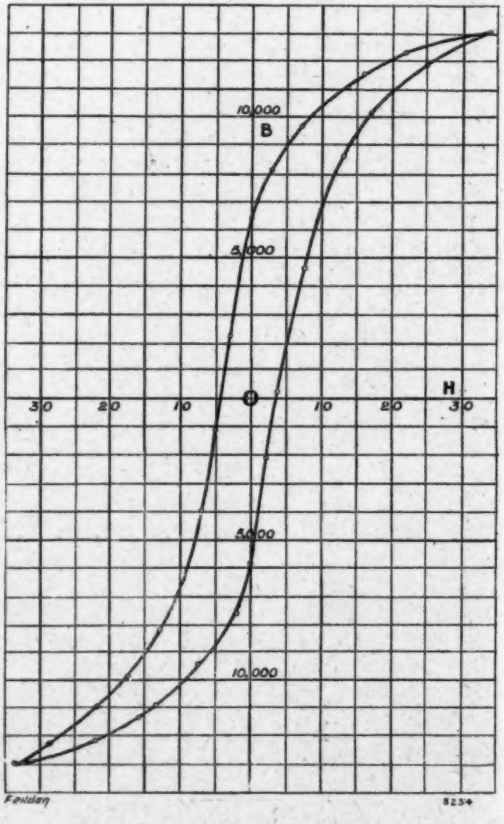


FIG. 8.—*B-H* CYCLE FOR MILD STEEL.

to error, as too low a flux density in the return path would imply a low permeability. Careful tests have been made on this point by turning down the outside of a drilled specimen and taking magnetisation curves between each turning down. The result, however, has shown that the reluctance of the return path may be taken as negligible whenever the external diameter of the specimen exceeds the diameter of the hole by more than an eighth of an inch.

It may be asked whether the drilling of so small a specimen does not injure the pin. No trace of any twisting has been found, although frequently looked for, and the consistency with which the results agree, even in different drillings, seems to show that the method is reliable.

The wearing of the drill is finally a point of considerable importance, and it is one upon which little experience has been obtained as yet. The experimental drill, which was first made up about six months ago, and has had a fair amount of use, has never been sharpened, and shows no sign of wear.

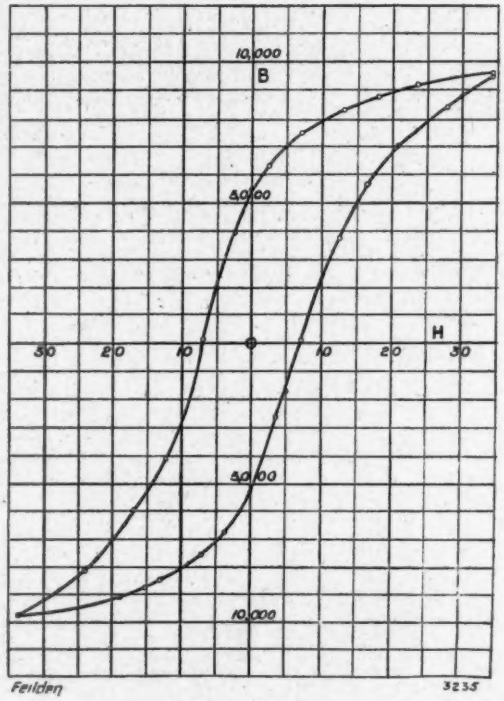


FIG. 9.—*B-H* CYCLE FOR WROUGHT IRON.

The sole point upon which experience is required is in the drilling of the specimens. No trouble has yet been found in drilling specimens of metal such as can be put on a lathe, but for larger castings, etc., some form of portable drilling machine would be necessary. Should any difficulty be found in getting the drill properly centred, it would probably be well to drill a shallow hole first, with an ordinary twist drill or rose-cutter, and any trouble as to wearing of the drills could be avoided by keeping a standard drill for a finishing cut. There is, however, no reason at present to suppose that such expedients would be necessary, and in any case all trouble would be avoided if small projections were left on the castings or forgings and cut off before drilling.

C. V. DRYSDALE.

Should not our Industries be Protected?

THIS vitally important question will undoubtedly agitate the minds of all thoughtful men of this nation in the early future. Our present fiscal arrangements, so competent experts say, will either keep this country in the forefront or be fraught with national disaster. Which is it to be? Opinions are strongly divided. We solicit the co-operation of our readers. Correspondence cordially invited.

MACHINERY, APPLIANCES AND PROCESSES.

The Editor of FEILDEN'S MAGAZINE cordially invites his readers to send him early particulars of New Machinery, Improvements, Novelties, etc., for inclusion under this section. No charge whatever is made for the publicity afforded or for illustrations, nor is any *quid pro quo* expected. FEILDEN'S MAGAZINE undertakes the whole of the cost, merely stipulating that proper details, photos, blue prints or tracings are supplied. If necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter.

RECENT IMPROVEMENTS IN WATER-SOFTENING APPARATUS.

THE use of softened water is of such great importance for many industrial purposes, and its advantages are so well known, that it seems almost superfluous to say more about this fact, especially where water-tube boilers and economisers are fed with hard water, as it has been impressed upon their users that the scale and sediments have become a serious matter for consideration on account of the wholesale waste of fuel and the danger of overheating.

The hardness of water is caused principally by calcium (lime) and magnesia in the form of bi-carbonates and sulphates. The bi-carbonates are soluble, but the simple carbonates are so little soluble that they may practically be regarded as insoluble.

If a solution of quick lime is added to the bi-carbonates in solution in the hard water a portion of the carbonic acid is removed from the bi-carbonates, thus forming the simple carbonates.

As these are insoluble they are readily expelled from the water, and appear in a very fine insoluble powder, which renders the water turbid.

To get rid of the sulphate of lime a solution of carbonate of soda is added. This causes double decomposition, simple carbonate of calcium and sulphate of soda being formed. While the latter remains in solution the carbonate of calcium is deposited as already described.

These processes being well known long ago, are now extensively employed in this country in connection with settling tanks, in order to clear the softened water.

Under these processes, by the combination of several tanks, the contents of which are in various stages of settlement, while the softened water is being drawn from one tank in which the water is already clear, the supply of softened water may be more or less continuous, though hardly absolutely so.

In most cases the tank system causes trouble and inconvenience. The necessary constant attention to the tanks must never be relaxed, and as this is not always possible, the time required for settlement is much protracted, and under ordinary circumstances the particles to be deposited require seven or eight hours to reach the bottom of a tank about four feet in depth.

Now it is obvious that if these four feet are divided into a number of shallow layers, the clarifying will be completed in a shorter time in proportion to the depth of each layer.

In the apparatus (Beissel's patent) recently placed on the market by the Baker's Patent Appliances Co., Ltd., of Scarborough, this principle is utilised, and by employing the apparatus to be described, it is claimed that large volumes of water are softened and clarified within a relatively short space of time.

Referring to the figure, *A* is the inlet pipe for hard water; *B*, a small tank divided into two parts, one part of which receives the water to be softened, the other contains the solution of soda; *C* is another small tank which contains the automatic arrangements for regulating the flow of hard water, of lime, and of the solution of soda. This automatic arrangement is so regulated that upon the stoppage of the supply of hard water the flow of lime water and of soda also stops to avoid waste, and, further, it exactly regulates the proportion of lime water and soda added to the hard water according to the adjustment of each, which is made when the apparatus is started.

The lime mixture is made in the cylindrical

tank *G*, and the flow of this tank is regulated in proportion to the flow of hard water, so as to supply exactly as much as is required for the softening of that water. Any waste of lime is thus avoided, and the solution of quick lime is maintained at a constant strength.

The hard water, as soon as it enters the apparatus and is mixed with the re-agents, becomes turbid and passes down the central tube. After reaching the bottom of the conical well of the tank it then begins to ascend outside this central tube through a number of spaces which are formed by hopper-shaped divisions, the spaces between each of these being of equal depth, and the distance from the centres of the exit of each of these spaces being of equal length the water rises steadily in these spaces, passes through each of them at an equal speed. There is no stagnation in any one of the spaces, as the resistance in each space is equal owing to its being of equal length to all the others, and therefore the whole volume of the water is equally dealt with.

The passage of the water through these shallow spaces has the immediate effect of clarifying the turbid water, and the deposit collecting upon the inclined surfaces attracts other particles of lime which are passing over it in close contact.

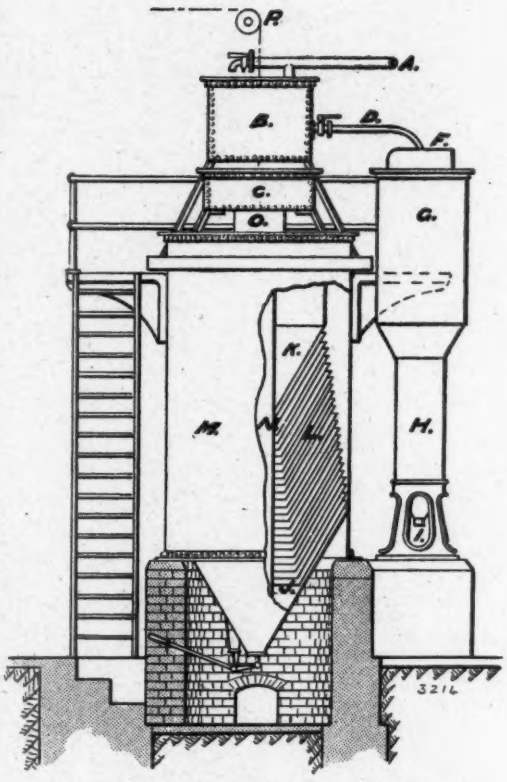
The clearing of the water, it is claimed is so effective as to render unnecessary the process of filtration, a step which removes one of the greatest drawbacks in connection with the ordinary system of water-softening.

The deposited lime slips down the inclined surfaces of these divisions and collects in the conical well at the bottom of the tank, from whence it is discharged by a valve daily.

The softened water passes out by the overflow pipe near the top of the apparatus, and is perfectly clear and ready for use.

The only attention the apparatus requires to keep it in perfect working order is the replenishment of the soda solution tank daily, and supplying a definite quantity of lime into the mixer *G*.

This, with the flushing out of the sludge from the bottom of the tank, may be done in from a quarter to half-an-hour, after which the apparatus is left to itself for the rest of the twenty-four hours.



BEISSEL'S PATENT WATER-SOFTENING APPARATUS.

It may be mentioned that salts of iron and alumina, and also grease and oil, are eliminated, and hot as well as cold water is thoroughly softened.

In the Bruun-Lowener system, which is being exploited by Messrs. Lassen & Hjort of 52, Queen Victoria Street, London, E.C., there is also an arrangement whereby a certain quantity of chemicals is mixed with a certain quantity of water in order to precipitate the hard substances, but the process of filtration has been retained.

The mechanical arrangement for mixing the water is as follows :—

The crude water is led through an inlet pipe *K*, into the oscillating receiver *C*, placed in a frame, and resting on a pivot on each side. The oscillating receiver is divided into two chambers, each of a triangular section, and as soon as one chamber is full

of water the centre of gravity is moved so far out from the vertical axis of the pivots that the momentum compels the receiver to tip and empty its contents into the mixing tank *B* below.

The next chamber then comes underneath the orifice of the pipe *K*, gets full of water, and the receiver tips to the other side.

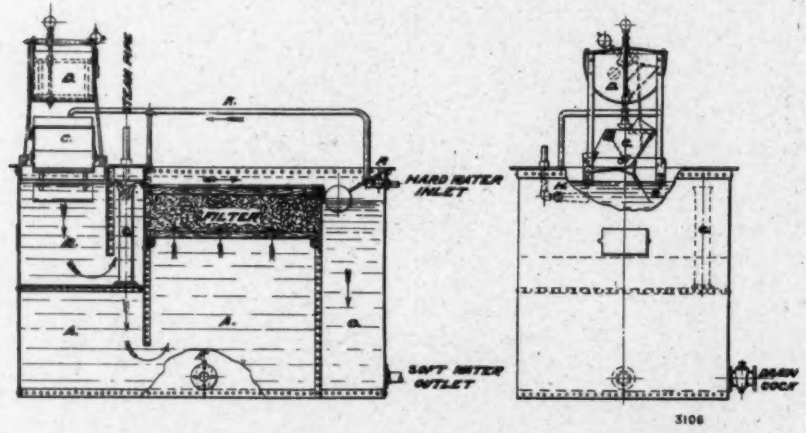
In this way small quantities of water are taken out continuously and automatically, and to these small quantities a certain amount of chemicals is added in the following way :—

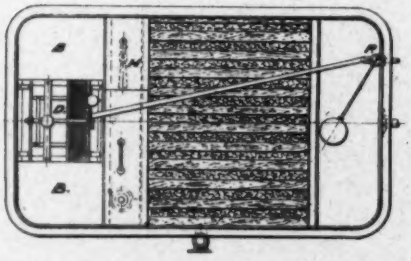
Above the oscillating receiver a chemical reservoir *D* is fixed containing the chemicals. In the bottom of this reservoir a valve is fitted, and every time the oscillating receiver tips, a trunnion fixed on the side of same touches the end of the vertical rod, which transfers the motion to the horizontal lever on the top of the chemical tank, and at each lift of the lever the valve in the chemical reservoir is opened. The opening of the valve can be regulated by an adjusting nut fitted on the end of the valve spindle, so as to allow more or less of the chemical solution to pass into the water in the oscillating receiver below.

It will thus be seen that a certain amount of water is mixed with a certain amount of chemicals, and the proportion between these two will always remain the same for any quantity of water passing into the oscillating receiver, as this will not tip before the one chamber is full.

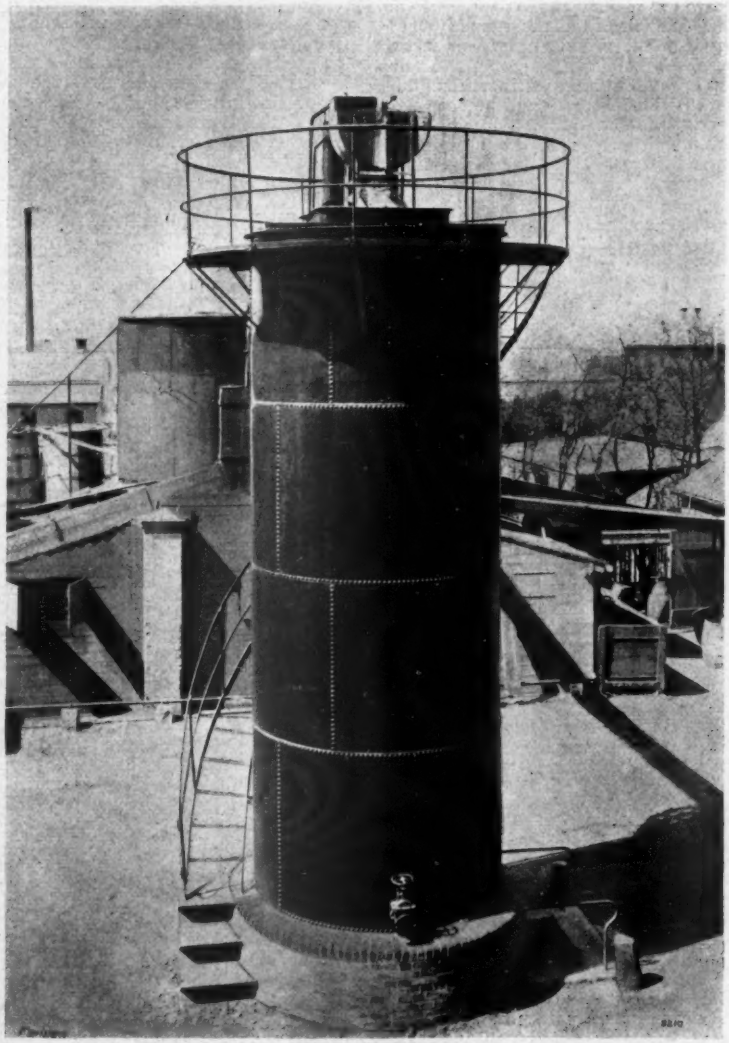
As stated above, the chemical re-agents generally used in this apparatus are a solution of quick lime and soda ash, or caustic soda.

When quick lime is used in the solution it is necessary to keep this in constant motion, as the strength of the lime solution is about 10 per cent. This is effected by means of an agitator fixed inside the semicircular vessel. A parallel rod fixed to the one side of the oscillating receiver transmits the motion from it to the agitator, and every time the oscillating receiver tips, the con-





DETAILS OF THE BRUUN-LOWENER WATER-SOFTENER.



THE BRUUN-LOWENER WATER-SOFTENER.

tents of the chemical reservoir are effectually stirred.

The advantage of using lime milk instead of lime water is that the strength of the chemical solution can be ascertained before putting it into the chemical reservoir in the softener. Further, as the strength of the lime milk is about 100 times more than that of saturated lime water, it will be seen that the settling tanks can be reduced in the inverted proportion compared with apparatus using lime water only as a precipitating agent.

The Bruun-Lowener water-softener contains no so-called "saturator." When water is led through a tank filled with quick lime to get saturated with same, the strength will vary considerably according to the temperature of the atmosphere. Thus, for instance, 730 lbs. of water at a temperature of 60 degs. Fahr. are required to dissolve 1 lb. of lime, whereas only 130 lbs. of water at a temperature of 212 degs. Fahr. are necessary.

After having left the oscillating receiver the mixture of water and chemical re-agents flows down to the mixing tank *B* below, where it is effectively stirred by means of an agitator fixed underneath the oscillating receiver. From *B* the water passes underneath the partition into a heating chamber *H*, where it is heated to about 150 degs. Fahr. by either live or exhaust steam, whichever is available.

It is a well-known fact that the chemical process is considerably facilitated when the water is heated. But in many cases no steam is available, and, therefore, the chemicals must have more time to make their action felt, and consequently the size of the settling tanks will have to be increased. Where exhaust steam is available for heating purposes the softener can, of course, also be used as feed-water heater, and the grease contained in the steam is practically taken out by the alkalies.

From the heating chamber the water passes through a by-pass pipe to the settling tank, where the precipitation takes place, and, owing to gravity, the water rises through the filter *I*, passes over the edge of the partition between the storage tank and settling tank, and is ready for use.

The filter consists of wood-wool tightly packed between two rows of wooden bars, and whenever necessary the filtering material can easily be taken out, cleaned and rinsed, and used over again.

The settling tank is provided with a manhole and sludge-cock, so as to remove the impurities precipitated to the bottom.

The inlet pipe for the crude water is provided with a ball-valve with the ball floating in the storage tank, and in this way the inlet of the crude water to the softener is automatically stopped when the storage tank is full of water.

It is claimed that the Bruun-Lowener water-softener has been used with the greatest success for purifying greasy condensed water, the same patent mixing apparatus being used, and only some other chemical re-agents being employed for extracting the grease.

MACHINE FOR FACING AND EDGING FLANGED PIPES, etc.

On page 156 we give an illustration of a patent machine made by Geo. Richards & Co., Ltd., Broadheath, near Manchester, which has met with ready sale, and is in great demand, and gives, we understand, universal satisfaction.

It has been designed for facing and edging flanged pipes, elbows, bends, tees, and facing and boring seats for valves, but is also adapted for a general class of boring, and as, in the case of the machine shown, the table is fitted with automatic cross feed, and the spindle slide with automatic vertical feed, the machine becomes a valuable tool for milling.

The capacity of the machine is as follows: — Faces and edges flanges, up to 36 ins. diameter; dimension of top table, 3 ft. square; plain table, 5 ft. by 3 ft.; automatic longitudinal traverse of table, 54 ins.; automatic cross traverse of table, 48 ins.; centre of spindle adjusts from 8 ins. to 40 ins. above top table, and 12 ins. to 44 ins. above plain table; bed, 8 ft. long from face of upright.

The spindle of the standard machine of this class adjusts from 8 ins. to 28 ins. above the top table and from 12 ins. to 32 ins. above the plain table It is not infrequently that Messrs. Geo. Richards meet clients' varying requirements in this way.

The facing head slide carrying the tool moves automatically both ways, and has a roughing feed of 12 or 16 to the inch inwards, and a finishing feed of 8 to the inch outwards, leaving the head ready for another flange, or trueing up the edge, which is done by feeding the table automatically at 16 or 32 to the inch. The spindle has 24 speeds, ranging from 2 to 54. The feeds are by positive gears, and all exposed gears are protected by properly fitted guards.

It will be noticed that the machine is motor-driven. The motor is a variable speed motor mounted on an extension of the base

of the machine, and the drive from the motor to the machine is by Renold's silent driving chain, and the drive to the quick traverse of the table by a small countershaft placed behind the upright of the machine, and driven from a small pulley fixed on end of motor shaft near the chain wheel.

The makers inform us that they have sold over 250 of this class of tool, and they have the machines constantly in progress at their works.

NEW PATENT SWITCH.

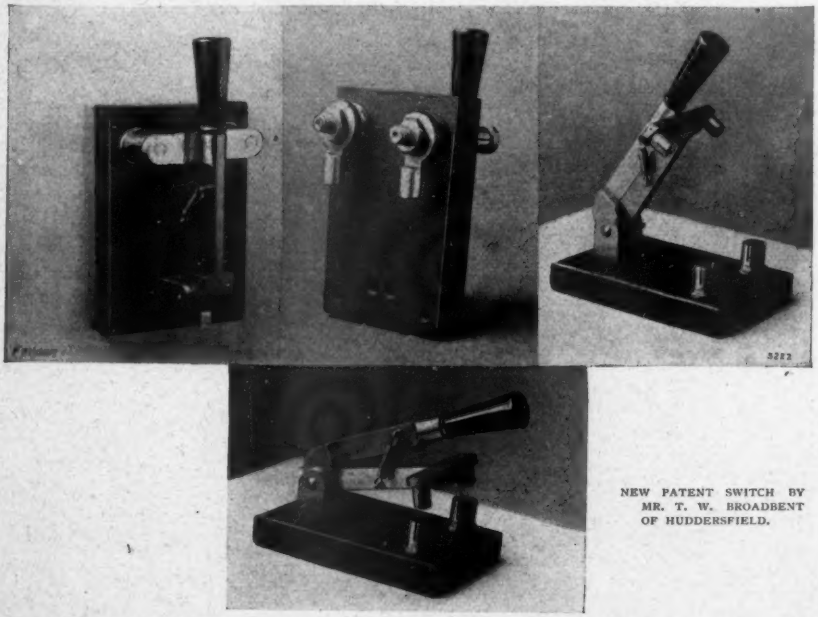
THE accompanying illustrations show an example of a switch recently patented and now being manufactured by Mr. T. W. Broadbent, of the Victoria Electrical Works, Huddersfield.

The improvement claimed consists in the novel method adopted for making contact. It will be seen from the photographs that the plugs on the crossbar are slit across in four places, so that when the switch is closed the plugs, which are slightly tapered, are forced into the sockets, the latter being expanded at the top half, thus making a more effective contact than is obtainable by means of the usual sliding arrangement. For ensuring a quick break the lever and double spring method has been adopted.

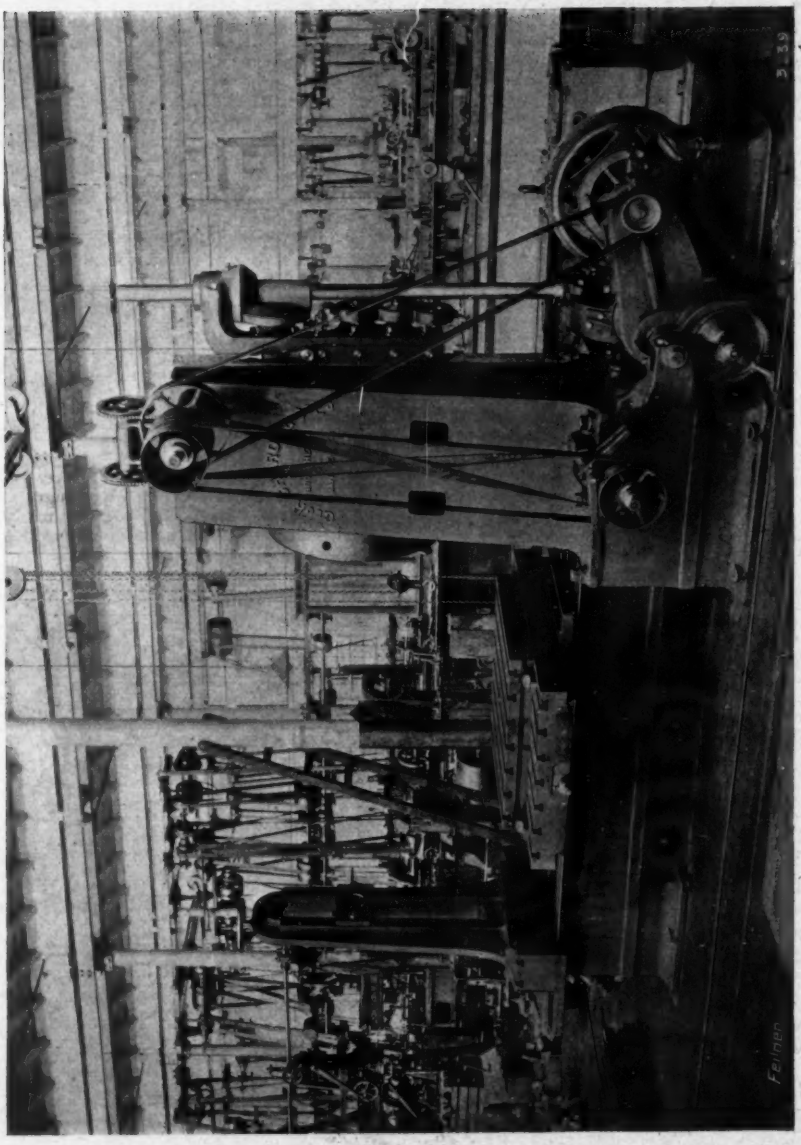
In designing the switch the question of renewing parts has been kept well in view, so that in the event of a dead short occurring, sufficient to burn up the contact pieces, the damaged parts can be removed and replaced in two minutes. The switches shown in the photographs are for a current of 100 amps.; they are, however, made in sizes capable of dealing with anything between 50 and 500 amps., and in either the double or single pole or change-over type.

"WIRED REFRAX" GLASS.

DURING the last few years, the importance of having mills, factories and workshops constructed with all materials of a fireproof character, has been impressed upon all who have to do with the design of buildings; and it has been found that many times fires have spread more rapidly, and



NEW PATENT SWITCH BY MR. T. W. BROADBENT OF HUDDERSFIELD.



MOTOR-DRIVEN MACHINE FOR FACING AND EDGING FLANGED PIPES, ELBOWS, BENDS, ETC., BY MESSRS. GEO. RICHARDS AND CO., LTD., BROADHEATH.

have caused more damage, through the fact of the windows falling in, owing to the heat of fire in the interior, thus enabling the burning materials to get more air for combustion.

In order to avoid this serious defect in the structure, a sheet of glass has been designed, having wire netting embedded in its centre. This remedies the tendency to collapse when subjected to fire, and certainly eliminates, to a very great extent, the danger of the fire spreading. But, unfortunately, this is done at a sacrifice; the available light entering the building being decreased, owing to the obstruction of the wire netting.

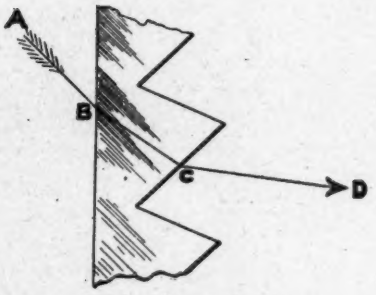
In order to overcome this difficulty, a new patent glass has been placed upon the market, which has all the fire-resisting qualities of the ordinary wire-glass, and at the same time many advantages. It is claimed that this glass (which is known as "Wired Refrax" Glass) will not only give more light than ordinary wired glass, but will transmit more light into an interior than even sheet or polished plate glass without wire. This may seem strange, but a glance at the diagram will show that this glass gathers rays of light, which, in an interior lighted by means of other glass, are lost by being dissipated on the floor just inside the window, and throws them right into the interior in a horizontal direction. The diagram shows an enlarged section of the glass, and the direction of the entering ray of light, also its path in the glass itself, and after leaving the window in the interior.

The principle of construction is the utilisation of the power of prisms to refract light. Thus, when a ray of light strikes a prism, it is deflected from its course by an amount depending upon the angle at which the ray strikes the prism; and on emerging from the prism it is again deflected to an extent depending upon the angle of the prism.

Thus, in the diagram, when a ray of light *A* strikes a window of wired Refrax glass as at *B*, its direction is reflected in the glass, and again on emerging, its final direction in the interior of the building being in the direction of *C D*.

Wired refrax glass is made in large sheets with prisms of various angles to suit various positions, and also for roof lights. It is about ¼ in. thick, and can be cut to any shape or size. It is perfectly flat on one side (the outside of window when glazed), while the other side is formed of a series of prismatic projections running horizontally across the sheet.

Seeing that the glass has an irregular surface, it may be thought that this surface will



SECTION OF "REFRAX" GLASS.

catch the dust, and require frequent cleaning. This, however, is not so; in fact, if the dust-catching surface (*i.e.* the upper edges of the prisms) were painted black, it would not interfere with the light-transmitting properties of the glass.

Objects cannot be distinguished through it, thus preventing being overlooked from the outside, and preventing employees looking out from the inside, added to its other advantages that it is missile proof, wired refrax is a distinct acquisition.

The Union Plate Glass Co., Ltd., Pocket-Nook, St. Helens, are the sole manufacturers.

A COLOSSAL "BUFFOLINE" PINION.

WE illustrate a production of a British firm which shows what can be made in the way of noiseless gearing of colossal dimensions for heavy pump driving.

A LARGE "BUFFOLINE" PINION

This pinion is 2 ft. 6 in. diameter, 5 in. wide, has 47 T, 2 in. circular pitch, and will transmit 120 b.h.p. The sole rights for the manufacture of these pinions are in the hands of The "Buffoline" Noiseless Gear Co., Levenshulme, nr. Manchester.

ELECTRIC WINDING-GEAR.

THE subject of our presentation plate this month is an electric winding-gear which has just been supplied by Messrs. Ernest Scott & Mountain, Ltd., Electrical and General Engineers of Newcastle-on-Tyne, England, to the Heckmondwike Collieries for winding from a staple about 100 yds. deep.

The winding-gear consists of one 4-pole open-type electric motor, capable of working up to 50 e.h.p. at a speed of about 600 revs. per minute, and at the end of the motor shaft an automatic electric brake is fitted which sustains the load immediately the current is switched off, the coils of the electro magnet being in circuit with the armature of the motor. Immediately the current is switched on to the motor the armature is attracted by the electro magnet and releases the brake wheel. The motor drives through a train of gearing (the first motion pinion being forged steel machine-cut) into a machine-cut cast-iron spur-wheel, which is supported by a countershaft on which a pinion is carried, gearing into a spur-wheel on the drumshaft. The drum is 3 ft. 6 ins. in diameter by 2 ft. wide, lagged with elm with strong cast-iron sides, a brake-strap being fitted on one side which is controlled by the attendant.

An indicator is provided, which shows the position of the cages in the shaft; this is driven by machine-cut wheels from the shaft.

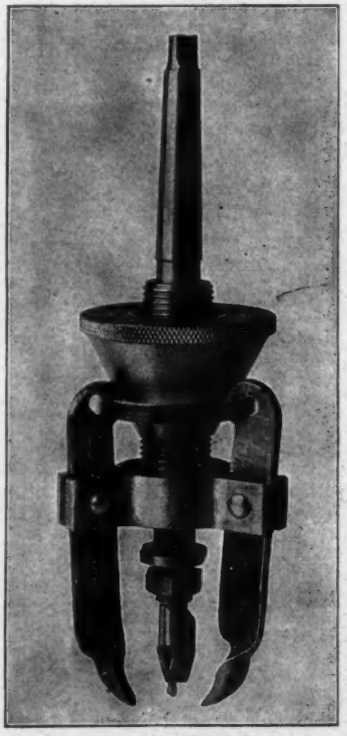
The whole gearing is mounted upon a cast-iron bedplate made in sections for getting down the pit and into position by the staple. The electric motor on the winding-gear is controlled by a special type of liquid reversing and regulating switch.

The dynamo supplying current to the winding-gear is also of Messrs. Scott & Mountain's multipolar type, giving an output of 50 kilo-watt maximum, and is driven at bank by a horizontal engine, the current being taken through cables 1,030 yds. in length down to the winding-gear motor.

Winding gears of this type are made in all sizes by Messrs. Ernest Scott & Mountain, Ltd.

A USEFUL DRILLING MACHINE ACCESSORY.

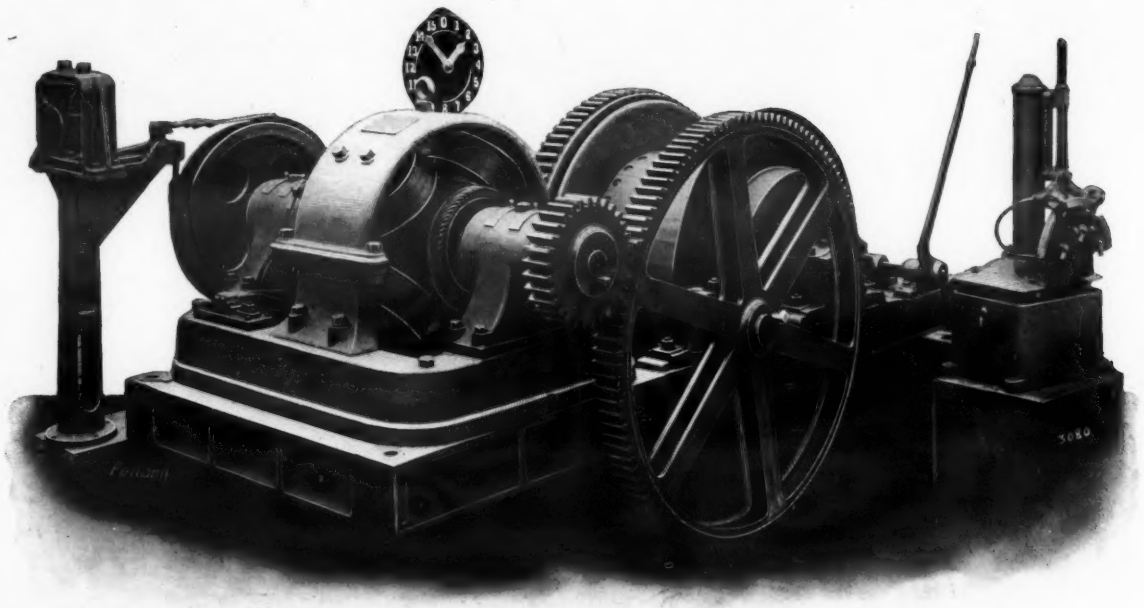
WE have received particulars from Mr. W. H. Harrap, of Salford, of a useful drilling-machine accessory, which he has recently patented and put upon the market. It is claimed that this device does away with the necessity for an expensive special centring machine in workshops where the amount of small turning would ordinarily warrant the purchase of such a special tool, while in the smaller class of shops it performs more rapidly and far more perfectly the operation commonly and clumsily done with dividers and centre-punch. The device consists of a drill shank and centring vice, combined with and arranged to fit the spindle of an ordinary drilling-machine. Four sizes are supplied, capable of centring work ranging from the smallest sizes up to 6 ins. in diameter.



A DRILLING MACHINE ACCESSORY.

SUP

Supplement to FEILDEN'S MAGAZINE.



ELECTRICAL WINDING GEAR BY MESSRS. ERNEST SCOTT & MOUNTAIN, LTD.,
CONSTRUCTED FOR THE HECKMONDWIKE COLLIERIES, LTD.

See page 158.

Having fitted it to the drilling-machine, the piece of work to be turned is brought within the jaws of the vice, three in number, which are caused to grip by a screwed cone or wedge. These close in so as to bring the centre of the work dead in line with a small drill, and upon the machine being started, an ideal "centre" is obtained. It is claimed that this device is much cheaper than, and quite as efficient as a special centring machine, while it takes up no floor space and requires no independent driving.

NEW PUMPING PLANTS.

THE pumping plants illustrated and described hereunder are of the well-known type made by the Drum Engineering Co., of 27, Charles Street, Bradford.

For the benefit of those who may not be conversant with the principle of the "Drum" pump, it will suffice to state that this type is in effect a combination of the centrifugal and direct-acting piston types, possessing the capacity of the one with the power of the other.

It consists simply of a revolving piston which engages with a revolving valve or cylindrical drum in such a way that when the revolving piston moves round from the revolving valve a vacuum is formed, into which the water flows, and is forced in the front face of the piston.

The water passes through in practically one continuous stream, and the momentum of the moving body of water is taken advantage of to assist the centrifugal action of the revolving piston.

These pumps have no valves to get out of order, and being positive in action their capacity is in proportion to the speed they are run.

Fig. 1 shows a "Drum" pump made specially strong for lifting sugar jelly at a slow speed against a 90 ft. head. It is

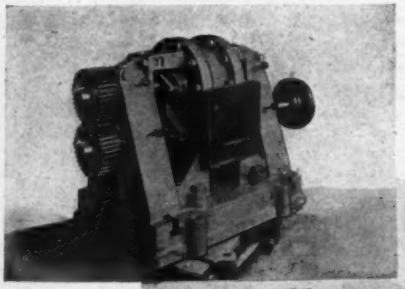


FIG. 1.

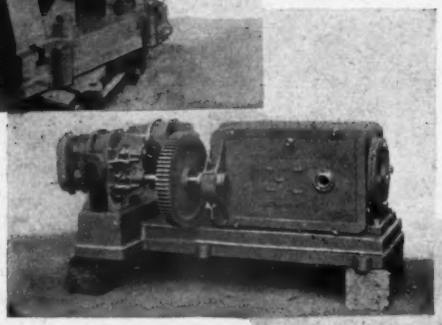


FIG. 3.

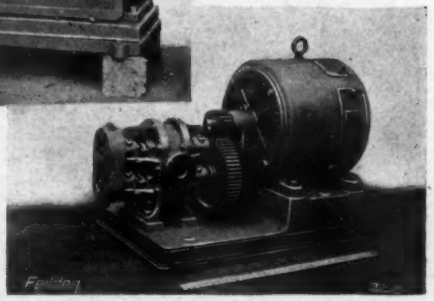


FIG. 2.

RECENT PUMPING PLANTS BY THE DRUM ENGINEERING CO., BRADFORD.

arranged for coupling direct to a steam engine. Fig. 2 shows a pump geared direct to a 3½ b.h.p. motor. This plant, which was shown by Messrs. Mavor & Coulson at the Glasgow Exhibition, is capable of lifting 3,200 gallons per hour. Fig. 3 shows two pumps, each capable of lifting 3,200 gallons per hour to a height of 50 ft., geared to an electric motor by Messrs. Mavor & Coulson. The gearing is arranged so that each pump may be worked independently of the other, or both together at will. The suction and delivery flanges of the pumps have a 2-in. bore.

The two pumps shown in Fig. 4 are mounted on the same base-plate with a vertical steam engine between them. The pumps are driven from the shaft by means of friction clutches, so that they may be worked either independently or together. The plant has been specially designed for brewers, and the pumps are constructed throughout of gun-metal. They will each lift 12,000 gallons per hour against a 80-ft. head.

The pump shown in Fig. 5, with the hand-gear at each end, has been designed to meet the special requirements for countries where manual labour is cheap and repairs incident to steam or electric power difficult and costly. There being nothing that will easily get out of order, pumps of this class should be in great demand for out-of-the-way places. At 30 revolutions of the handles per minute these pumps will lift 1,800 gallons of water per hour.

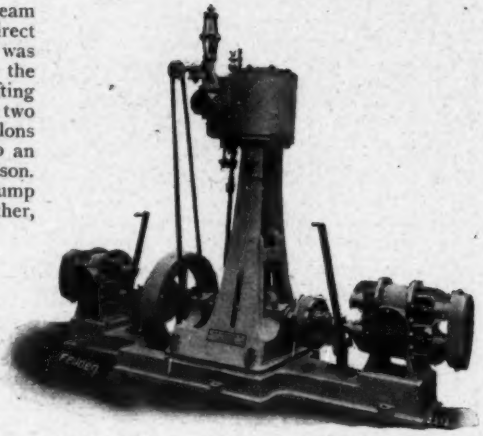


FIG. 4.—RECENT PUMPING PLANT BY THE DRUM ENGINEERING CO.

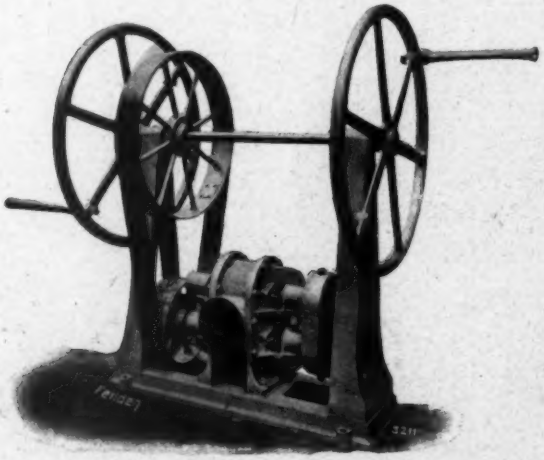


FIG. 5.—RECENT PUMPING PLANT BY THE DRUM ENGINEERING CO.

MESSRS. W. H. ALLEN & CO.'S NEW THREE CYLINDER COMPOUND ENGINE.

IN our last issue, although we described fully this interesting high-speed engine, at the time of going to press we were unable to include the indicator cards and efficiency diagram, taken at the trials referred to therein. An opportunity has now been afforded us to reproduce them, and in Fig. 1 are shown samples of the indicator cards taken during the test. This set was used in the construction of the combined diagram shown in Fig. 2, which is sufficiently self-explanatory. The three indicator diagrams, *HP*, LP_1, LP_2, refer to the high-pressure cylinder, low-pressure cylinder No. 1, and low-pressure cylinder No. 2 respectively, the order in which the cranks lead and follow being that given. Non-steam-jacketed cylinders have been adopted, and the cylinders are lagged with asbestos only. As will be seen from the combined diagram, the expansion follows very closely the adiabatic curve. Fig. 3 shows a number of curves deduced from the actual trial made, giving the efficiencies and steam consumptions throughout

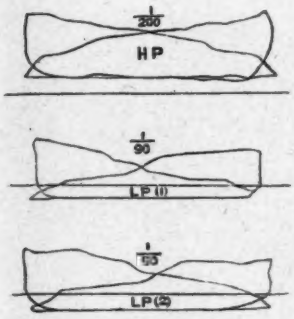


FIG. 1.—INDICATOR CARDS FROM ALLEN ENGINE.

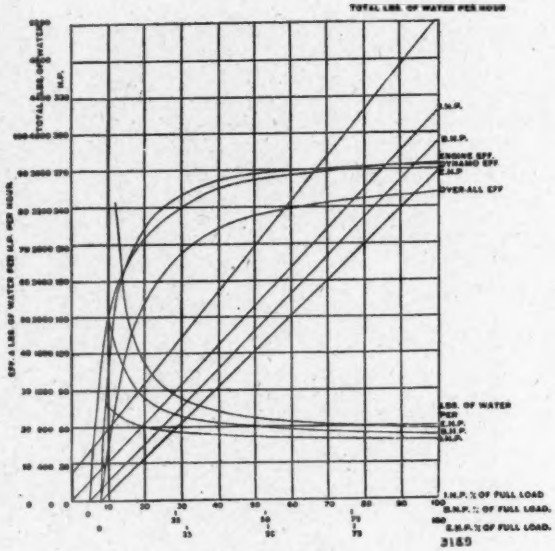


FIG. 3.—EFFICIENCY DIAGRAM.

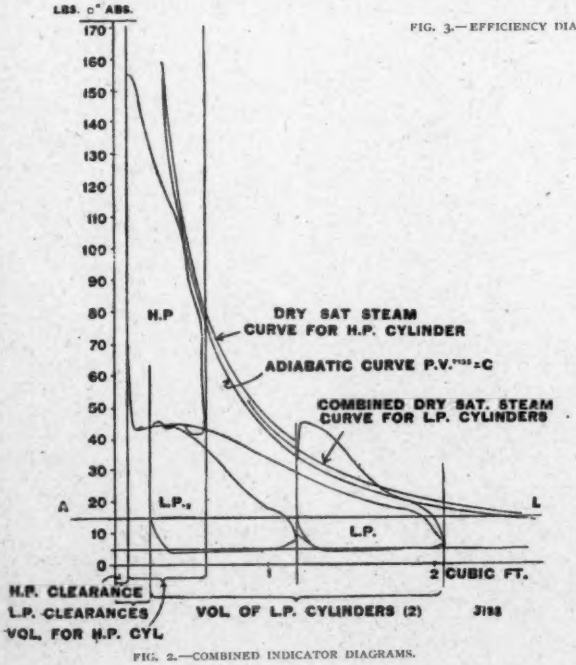


FIG. 2.—COMBINED INDICATOR DIAGRAMS.

THE MILITARY HEAVY MOTOR WAGON TRIALS.

THE illustrations accompanying this article represent some of the self-propelled lorries that took part in or were entered for the recent trials undertaken by the War Office for the purpose of ascertaining the suitability of heavy motor wagons for various military purposes.

The whole of the proceedings were of a most interesting character, and the report of the military authorities will be awaited with eagerness.

The first prize of £500 goes to the steam lorry No. 6, built by the Thornycroft Steam Wagon Co., Ltd., of Basingstoke; the second prize of £250 to Messrs. Edwin Foden, Sons, & Co., Ltd., of Sandbach, for steam lorry No. 3; and the third prize of £100 to the Straker Steam Vehicle Co., Ltd., of 9, Bush Lane, London, for steam lorry No. 5.

The following are details of specifications supplied by the manufacturers of the various competing cars :—

No. 1.—BROWN & MAY, LTD.—*Steam Lorry.*

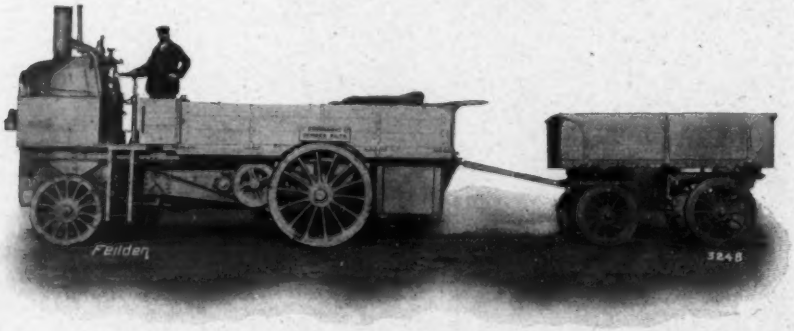
This vehicle is 18 ft. long by 6½ ft. wide, extreme measurements. The main frame, made of channel steel, is supported upon the main axle by springs, and at the front end by an axle with springs, which is upon the ordinary divided method for steerage purposes. All wheels are of wood, the hind pair having tyres 9 ins. wide and the front tyres 5 ins. wide.

The boiler is of the "Toward" class, and suitable for the use of coal or coke as fuel. The gauge working pressure is up to 225 lbs. per sq. in. Free blowing safety valves are fitted, and "Reflex" unbreakable water-gauges are used. The boiler is fed, when the engine is running, by a feed pump, and by an injector of the most reliable type when the engine is at rest. There are a sufficient number of screwed plugs for cleaning the boiler inside from mud and other deposits, and large doors for tube cleaning.

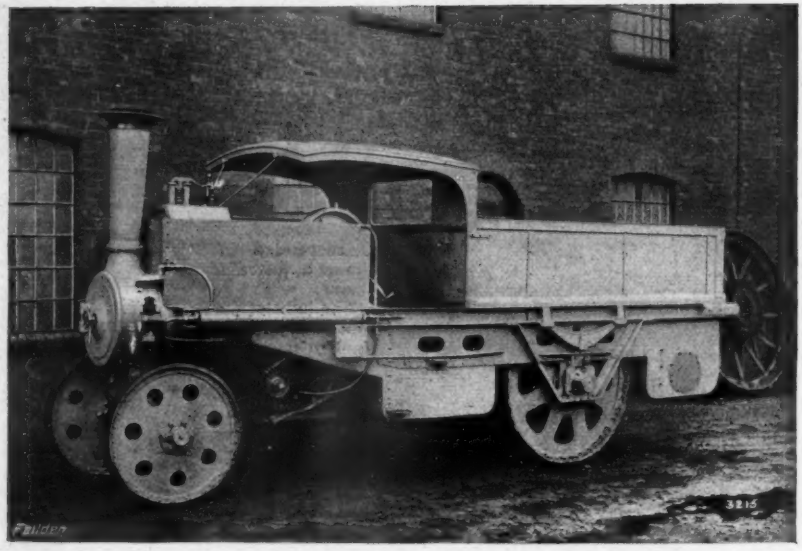
The engine is of the horizontal compound type, having cylinders 4½ ins. and 7½ ins. diameter by 6 ins. stroke, making 600 revolutions per minute, and having the piston-rods working with an approved metallic packing. All parts of the engine are enclosed in oil casing, whereby good and reliable lubrication is assured by the "splash" method. The steam is lubricated before entering the cylinder by a sight-feed lubricator. The cylinder end of the engine is carried by the main framing with a universal coupling, and by this means any twist in the main framing is compensated for, and no binding or undue strain is brought to bear upon the engine or gearing.

The gearing is spur and helical throughout, the spur being rings bolted to cast-iron centres, with turned and fitted bolts, and thereby allowing the renewal of gearing without having to loosen keys or bosses on the Bessemer steel shafts. The main axle is fitted with compensating gear. The gearing is in three speeds of three to eight miles per hour.

A special loading arrangement is fixed on the hind part of platform; this is worked by a friction hoist in connection with the crank shaft; a wire rope or chain running from the hoist to the hollow swinging crane, and passing through the centre to end by guide pulleys, and with the use of ordinary sheave blocks, enables one man to lift and dispose of goods in any position.



STEAM LORRY BY MESSRS. BROWN AND MAY, LTD



STEAM WAGON BY MESSRS. EDWIN FODEN, SONS AND CO., LTD.

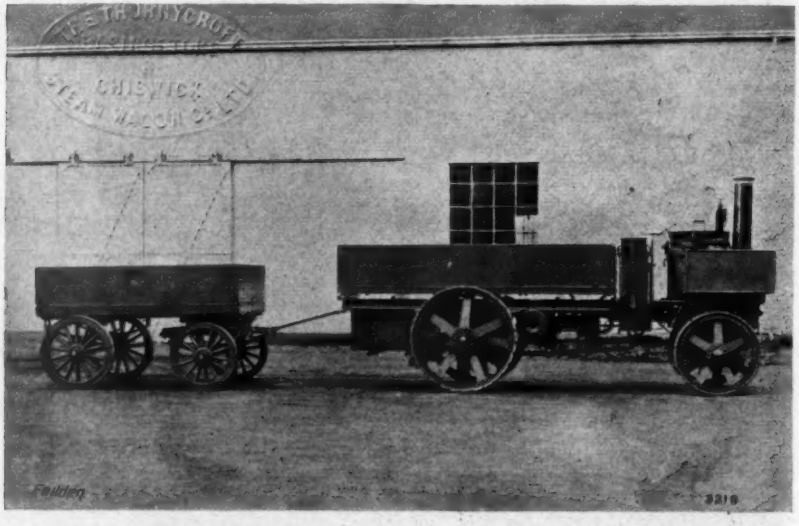
STEAM WAGON (NO. 7) BY THE THORNYCROFT STEAM WAGON CO., LTD.

No. 2. — Creek Street Engineering Company.—*Steam Lorry.*

The steam wagon works on a superheating system, in which a semi-flash coil generator is used, which is heated by a petroleum burner of the vaporising type, ordinary commercial petroleum, such as Russolene, being used.

The temperature of the steam is regulated by a regulator of special design, which proportions the flame of the burner to the amount of water entering the boiler, the water in turn being regulated by the steam pressure. The engine, which is carried on the front of the platform behind the boiler, has three single-acting cylinders fixed vertically, with cranks at 120 degs.

Equilibrium lift valves for steam and exhaust are fitted to each cylinder, which



STEAM WAGON (No. 6) BY THE THORNYCROFT STEAM WAGON CO., LTD.

are operated by cams on a countershaft. Two sets of cams are used, one for forward and one for back gear, and the steam cam in the forward gear is tapered in such a manner as to give a variable cut-off when moved laterally.

All pistons, connecting rods, valves, valve levers, and cams are of the same dimensions and interchangeable.

Transmission between the engine and driving wheels is by means of chains and gearing. The first drive of the engine to the countershaft is by a Reynolds silent chain, which reduces the revolutions two to one; then a further reduction of two to one is obtained by pinions in the balance gear-box, which is fitted on the countershaft.

From the countershaft to the driving wheels, transmission is by means of two Reynolds roller chains, which makes the final reduction of revolutions, this last reduction, being three to one. No change gear is used, and the balance gear-box is suspended in such a manner that it can be adjusted to take up the wear of the chains.

The hubs of the road wheels are of special construction, in which rubber cushions are used to take up all jar and vibration, and a powerful double brake is fitted on the road wheels, which is operated by the driver's foot.

Stability is given to the road wheels by means of horn plates, and water and oil tanks are suspended below the frame at the rear of the vehicle.

No. 3.—Edwin Foden, Sons & Co., Ltd.—*Steam Wagon.*

The general design of this steam wagon is of a novel and original character. The boiler, which is of the horizontal multitubular type, forms the front part of the framework. The

sides of the frame are constructed of strong channel steel, tied and braced together in such a manner as to secure great strength in the complete lorry. The main platform of the lorry is 9 ft. 4 ins., and below this is a lower platform or well, 9 ft. long by 2 ft. 9 ins. wide by 15 ins. deep, which can be used conjointly with the top platform, or separately as a secret chamber for ammunition or valuable goods.

The boiler is fired with coal or coke, but can easily be arranged to be fired with oil.

The wagon is driven by a compound steam-engine fixed on the top of the boiler, so as to be easily get-at-able and to work with dry steam.

The cylinders are 6 ins. and 4½ ins. diameter, and are fitted with a patent high-pressure gear, by means of which both cylinders can, in case of emergency, receive live steam from the boiler, and each cylinder exhaust independently into the chimney.

The reversing motion is of the ordinary link type, and the whole construction of engine and steering arrangement is so similar to our traction engines that an ordinary traction engine driver can easily handle the wagon.

The driving is transmitted by one pair of spur wheels, acting on a cushioned compenpensating gear, by two extra strong block chains working side by side.

The gearing is arranged for two speeds, eight to one and twenty to one.

The boiler is fed by two pumps, one driven by the engine, and the other a separate independent double-acting single-cylinder pump, which can be regulated from 2 to 150 strokes per minute.

The travelling wheels are made with cast steel hubs and double-dished steel plate sides, with ⅜ in. lapping plate, and shod with steel diagonals 2 ins. by ⅜ in.

The car is mounted on laminated springs with angle axle guards, containing the sliding axle boxes, similar to the modern railway carriage practice.

No. 4.—G. F. Milnes & Co., Ltd.—*Petroleum Lorry.*

This vehicle is 21 ft. long by 6 ft. 6 ins. wide. The wheel base is 12 ft. 9 ins. Floor space, 13 ft. 6 ins. by 6 ft. The frame is constructed of 7-channel steel, and will bear a total dead load up to 6 tons.

The motor is a four-cylinder hydro-carbon engine, the diameter of piston being 90 mm. and the stroke 120 mm. It is built on the Daimler principle throughout, with Daimler float-feed, governor, and patent water cooler of the marine condenser type. The number of revolutions per minute is 750, and the brake h.p. is 25. Lubrication is by automatic pressure to all engine bearings, water circulation by a gear-driven rotary pump. The oil is fed by pressure from a portion of the exhaust, ignition being by the Simms-Bosch magneto-electric system.

The transmission is by a single friction cone on the Daimler principle. The power is transmitted from the main longitudinal shaft through the differential gear wheels fixed to the back road wheels. The speed-changing gear is on the Cannstatt system, four speeds being provided. With this Cannstatt gear, the first and second and third and fourth speeds are each controlled by one lever, by which means, as the two couples of speeds are independent of each other when changing, neither couple affects the other set of gear-wheels. The Cannstatt principle for changing speed also automatically disengages the friction cone when either speed lever is actuated. The reverse speed is obtained by dropping into gear a special cog-wheel, giving a speed of four miles per hour.

No. 5.—The Straker Steam Vehicle Company, Limited.—*Steam Lorry.*

This vehicle is 18 ft 6 ins. long by 7 ft. in extreme width. The wheel base is 10 ft. 5 ins., and wheel gauge from centre to centre of driving tyres, 5 ft. 10½ ins. The leading wheels are 2 ft. 9 ins. in diameter by 5 ins. in width, and back wheels are 4 ft. 6 ins. in diameter by 9-in. tyres, the latter having stropes secured to same. The leading axle is mounted on a central pivot under boiler, and takes the weight of that portion of the vehicle through anti-friction bearings, thus obtaining a three-point support, which relieves the frame from any undue transverse strain, and secures great ease in steering

The body of the vehicle is constructed in well-seasoned timber, and framed up with removable stanchions and sides 2 ft. in height. The superficial area is 48 sq. ft.

The boiler is of patent water-tube type, and contains 70 sq. ft. of heating surface and 2·2 of grate area. The working pressure is 200 lbs. per square inch. It is constructed to the requirements of the Manchester Steam Users' Association; it is rivetless, affords special access for disconnecting and cleaning, and is provided with a superheater.

The engine is of the company's patent compound horizontal reversing type, having cylinders 4 ins. and 7 ins. by 7 ins. stroke at 400 revolutions per minute. The valve-gear is of the company's patent design, permitting of linking up. The power developed at 400 revolutions per minute is about 25 h.p.

Powerful brakes are provided.

Sufficient fuel is stored for carrying a day's supply.

The power is transmitted from engine to countershaft at two useful ratios, giving speeds at from 2 to 8 miles per hour. The countershaft also carries a sprocket pinion driving direct to back axle through the medium of specially constructed chain capable of withstanding a working strain of 20 tons.

The back axle is provided with a device for locking differential gear; it rotates in hard gun-metal bearings, and is, through the medium of axle boxes, secured to steel laminated springs, bearing on channel frame.

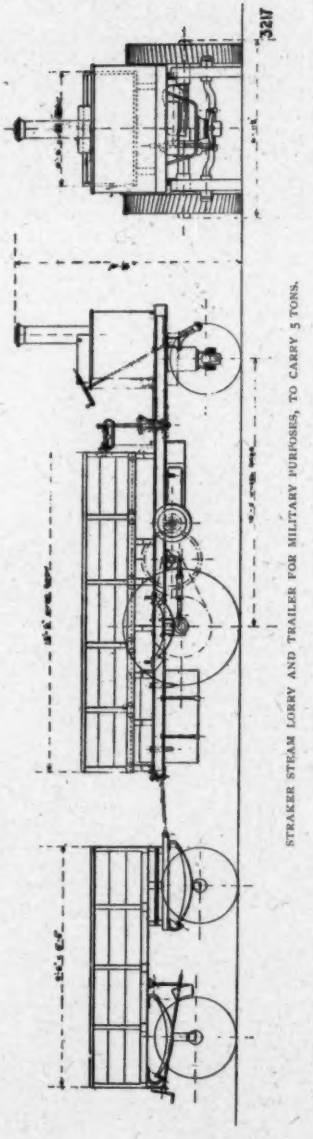
Adjustable radius rods are fixed, and keep the driving axle equidistant with the countershaft.

A four-wheeled trailer is connected to the back of the vehicle by a spring drawbar, the platform area being 45 sq. ft.

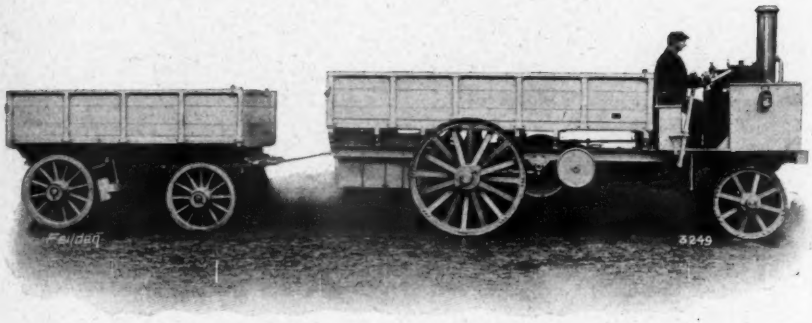
No. 6.—THORNYCROFT STEAM WAGON COMPANY, LTD.—*Steam Wagon.*

This wagon is of the company's standard type, capable of carrying three tons, and drawing a further two tons on trailing vehicle; it is fitted with a patent central fired watertube boiler, specially arranged for cleaning the internal surfaces, a most important feature when hard water, as is frequently the case, can only be obtained. The engine is compound, and fitted with piston valves provided with rings; it is entirely enclosed in a dustproof and oil-tight case, and is fitted with a constant radial valve-gear; the gearing is of machine-cut steel, and drives the road wheels by means of the company's patent spring-driving apparatus, which prevents the transmission of the road shocks to the gearing, and greatly reduces wear and tear. The springs are of the semi-elliptic pattern, the front axle being mounted so as to give the frame a three-point support to avoid all twisting strains when the wagon is going over rough and uneven ground. Steering is effected by worm-gearing, the axle being of the double-hinged pattern. One man is able to easily perform all the operations required in driving and controlling the vehicle. It is fitted with a steam brake capable of stopping the wagon in its own length when running at full speed. A steam jack and water-lifter are provided in the equipment. Solid or liquid fuel can be used, the bunkers having a capacity sufficient for 50 miles.

The differential gear may be locked by a friction braking device, which can be applied without getting underneath the vehicle.



STRAKER STREAM LORRY AND TRAILER FOR MILITARY PURPOSES, TO CARRY 5 TONS.



STEAM LORRY AND TRAILER BY THE STRAKER STEAM VEHICLE CO., LTD.

No. 7.—THORNYCROFT STEAM WAGON COMPANY, LIMITED.—*Steam Wagon.*

This wagon is specially adapted for use on rough roads and uneven ground, the steering axle being capable of an unusually great angle of tilt; and the driving and steering wheels being of large diameter. The boiler and engine are situated directly over the driving axle, the carrying platform being provided at the fore part of the vehicle. This arrangement gives the wagon greater power to get out of holes in soft ground, etc., and enables it to exert its full power as a tractor when it is not itself laden. The boiler and engine are of the same pattern as the standard wagon; it is fitted with three speeds, a winding drum, and one hundred yards of steel wire rope. A spring draw-gear is provided, fitted with the standard military draw-hook. The boiler is arranged that the fire-bars can be easily replaced by the liquid fuel burners, which are either of the spraying or vaporing type, according to the nature of the oil which may be available.

A condenser is provided, but is arranged so that it can be short-circuited or removed without interfering with other parts of the machinery. The boiler is fed by a pump driven from the engine, or by an auxiliary pump or injector. An exhaust feed heater is also provided; the differential gear can be locked in the usual manner, and the usual equipment of steam water-lifter, jack, etc., are provided.

No. 8.—WANTAGE ENGINEERING COMPANY.—*Steam Lorry.*

The boiler is of the locomotive type, but has two barrels in place of one; this allows of its being carried under the main frame; it also allows of a very large grate area, and gives ample clearance from the ground. The stoking is done through an inclined shoot fixed between the two barrels. The steam-working pressure is 200 lbs. per sq. in. Coke is used, but oil or wood can be burnt. A triple safety-valve is employed. Water is supplied by injectors, one of which is automatically controlled by a float; there is also a water-level indicator.

The engine has two cylinders, compound link motion reversing gear, piston valves, and is carried on a steel frame hung from the main frame. The stop-valve and reversing gear are actuated by one lever. The reversing and speed levers are arranged to interlock, so that the speed gear, of which there are three sets, cannot be changed when the engine is running.

The driving wheels, which are of steel, revolve upon a fixed axle attached to the main frame by laminated springs; they are driven by flexible steel wire ropes attached to the bosses at the end, and to an arm connected with the main gear at the other end. This system of driving allows the gear-shafts to revolve in fixed bearings.

The steering-gear is of the Ackermann type, actuated by screw and lever. The axle works in steel horn-blocks, and is connected to the main frame through laminated springs.

Block brakes, actuated by lever, are applied to each driving wheel, and there is also a block brake controlled by pedal on the spider of the compensating gear.

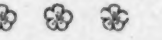
Both driving and steerage wheels are of large diameter, and are fitted with widening rings to enable the lorry to pass over soft ground.

A small steel drum containing 100 yards of steel wire rope is fixed to the back end of the main frame, and is drawn by worm-gear from the crank-shaft of the engine.

HOW GREAT BRITAIN IS MEETING FOREIGN COMPETITION.

4.—Automatic Conveying Machinery.

By GILBERT LITTLE, M.I.Mech.E., M.Inst.M.E.



IN his speech at the Wolverhampton Chamber of Commerce Dinner in January of last year Lord Rosebery predicted that the greatest war of the future would be the industrial contest of America and Germany against Great Britain for the markets of the world; and the ex-Prime Minister, like numerous public speakers and editors of hundreds of British newspapers, appeared to accept the common fallacy that at present British manufacturers are sadly behind their two great rivals in ingenuity and resource to produce labour-saving machinery, to improve our commodities and cheapen production. We are, so we are told, an industrial, but not an industrious nation. Few of our statesman and editors are pro-Boers, but many are pro-foreign in belauding the skill of our commercial rivals, and belittling the abilities of British manufacturers. We are, in the words of Lord Rosebery, "going on with a general feeling of a little more sleep, a little more slumber, a little more folding of the hands," and I suppose his lordship's praise of our competitors is intended to disturb this Olympian repose "on the banks of Asphodel," on which British manufacturers are said to be reclining.

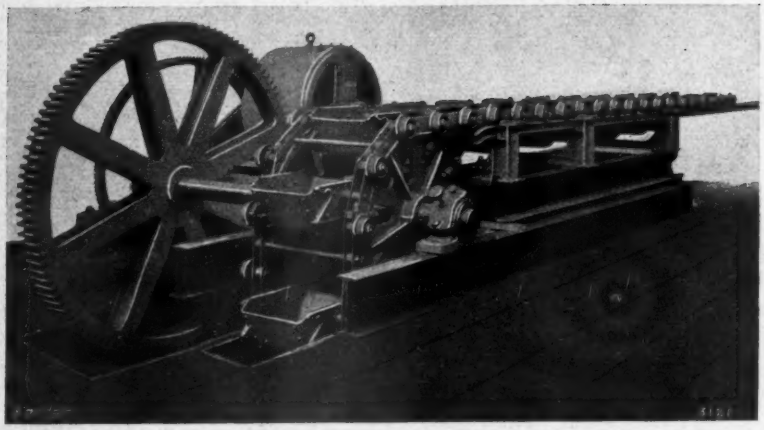
You lazy Lotus-eaters slumbering fell
Upon Olympian bed of Asphodel,
Sleeping like glutted gods after a feast,
Or after toil sleeps burden-bearing beast,
Unhappy on this sphere I flutter round,
To startle with a shout you sleepers sound.
Oft in that gilded chamber of the Peers
I've frightened noblemen with gruesome fears
That Britain's Empire was in fast decay,
And Britain's glory must soon pass away.
Alas, how sound you toilers sleeping lie,
E'en cry of "Trade, it passeth by!"
Will not awaken you from peaceful rest,
Or make you workers-hard at my behest:
You sleep as little children, void of care,
Despite my efforts to produce nightmare.

A greater number of articles has been written during the last three years about the manufacturing methods of our rivals than during the previous thirty years, and the writers one and all warn us that two formidable competitors have risen to wrest our commercial supremacy. This, it is said, cannot be obviated save by using the methods and copying the examples of our rivals. These articles have been copied in the American newspapers and handled in characteristic fashion. Like Lord Rosebery, the American editors picture Britishers not only asleep, but sleeping in American beds, and when awake sitting in American chairs, eating American-grown food, cooked in an American stove, and eaten from an American table. I do not blame the American editors, I blame those who have created this belief in America, by the undue prominence given in the columns of British newspapers to the alleged superior skill and greater abilities of Americans. This has been dinned into foreign ears and our own by these pro-foreign editors. Can we, therefore, wonder if the Americans believe we are in sore straits as to how to stay the decline of our commerce? In a copy just to hand of the *New York Tribune*, one of the most fair and staid of American papers, I find the following:—

"It is, to say the least, extremely flattering to Americans that the growing exports from the United States are receiving such general recognition abroad, and the calamity-howlers in this country should cease bewailing our misfortunes from excessive tariffs long enough to peruse a few of the leading British journals."

Yes—"leading British journals" have been great enemies of British manufacturers. As remarked by my son in the communication you printed in your August number, "British newspapers have done great injury to British trade by the erroneous assumption that American engineers are far ahead of us in labour-saving devices."

Who among us ever saw a paragraph about the failures and weak points of American traders, or a notice of a British success in an American journal



PART OF BUCKET COAL ELEVATOR AT THE PINXTON POWER STATION, GLASGOW, CONSTRUCTED BY MESSRS. THE MIRRLEES, WATSON CO., LTD.

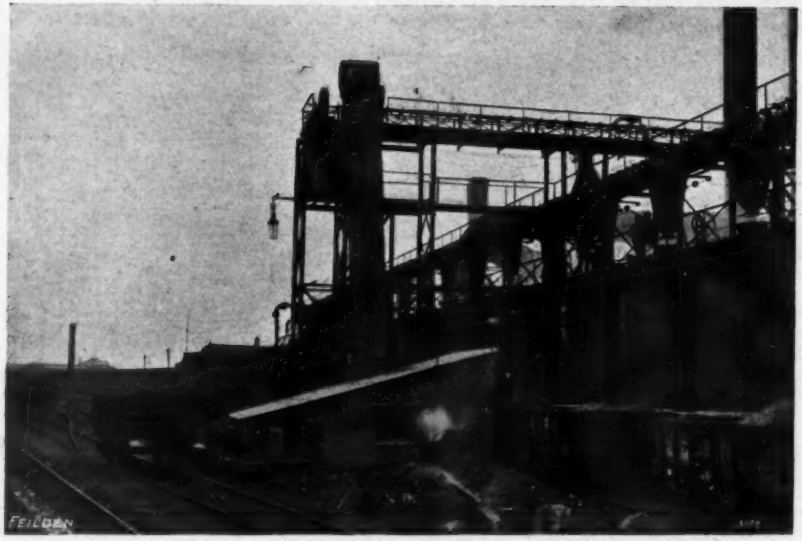
Some months ago I drew the attention of Mr. Chamberlain to the manner in which so many English newspapers belauded American to the detriment of British machinery, and the right hon. gentleman replied that he supposed the intention of the comparisons made by the writers was to stimulate improvement on the part of English manufacturers. In acknowledging the Colonial Secretary's letter, I pointed out that British engineers had been as successful in producing automatic machinery as their American cousins. The less extended use of such machinery in some industries in England, compared to American, is not due to lack of skill among the designers and manufacturers of self-acting devices, but is clearly traceable to the lack of enterprise among a number of English manufacturers in failing to take advantage of the engineering skill at their command. In that opinion I am supported by the distinguished president of one of our engineering institutions, who recently visited America, who wrote me :—

"I endorse the opinions you advance. The Americans are not ahead of us in the best features of engineering. In many directions of our various industries we have woke up, and are as much alive as our cousins on the other side, but in my opinion the owners or directors of many works require to be removed or vigorously shaken up; still, I am quite hopeful that numerous old-fashioned factories in England will soon be lifted out of their present unprofitable ruts by the new and younger generation imbued with your labour-saving enthusiasm and your belief in the skill of your own countrymen."

Let me pass in review the chief industries in which labour-saving machinery can be used to the greatest advantage, and I confine my remarks to the trades I am most familiar with, namely, flour-mills, breweries, gas and electric light works, power stations, iron and steel works, and collieries.

FLOUR-MILLS AND BREWERIES.

As we do not export grain, the ingenuity of the British engineer or millwright has never been required to design grain-loading machinery, but the elevators and conveyors at our seaports are certainly not inferior in self-acting efficiency and economy to American ship-discharging appliances; and as regards automatic conveying and elevating machinery in British and Irish mills and breweries, our methods for many years were, in the thoroughness of our automatic devices, far in advance of American, and our grain mills and breweries are still not less completely self-acting in the passing of the products to and from the numerous machines employed in the process of flour and beer manufacture. The first completely automatic flour-mill in the world was erected in 1880 for the late Mr. P. Boland at Dublin, by a firm of London engineers, where the author was general manager, and the first in England and Scotland the following year at Doncaster and Glasgow. From 1881 till



A TYPICAL COAL-HANDLING PLANT BY THE NEW CONVEYOR CO., BIRMINGHAM.

1886 automatic mills were erected all over the United Kingdom and Ireland, but it was not till the latter year that the complete self-acting system of manipulating the grain in mills by means of elevators and conveyors was introduced into American mills. So much for the priority and superiority of labour-saving devices for grain in British mills and breweries.

COLLIERIES.

With regard to the automatic handling of coal we possess a lead in labour-saving devices over America equally ahead. At hundreds of British collieries the self-acting machinery for the loading, sorting, and cleaning of the coal leaves little room for improvement In South Wales, the Midlands, Yorkshire, Durham and Scotland, the arrangement, efficiency, and economy of the automatic plant could hardly be made more perfect, as the coal tubs, as they are brought to the pit-bank are taken by a self-engaging chain to automatic tipplers, which discharge the coal in the tubs into mechanical sorting screens, which size it into the marketable products of large coal, medium, cobbles, nuts, beans, peas, and dross; and these various sizes and qualities are automatically loaded from the screens into the wagons by means of self-acting conveyor belts and bucket elevators. In the use of labour-saving devices at collieries, the Americans are certainly not ahead of us.

GAS, ELECTRIC LIGHT WORKS AND POWER STATIONS.

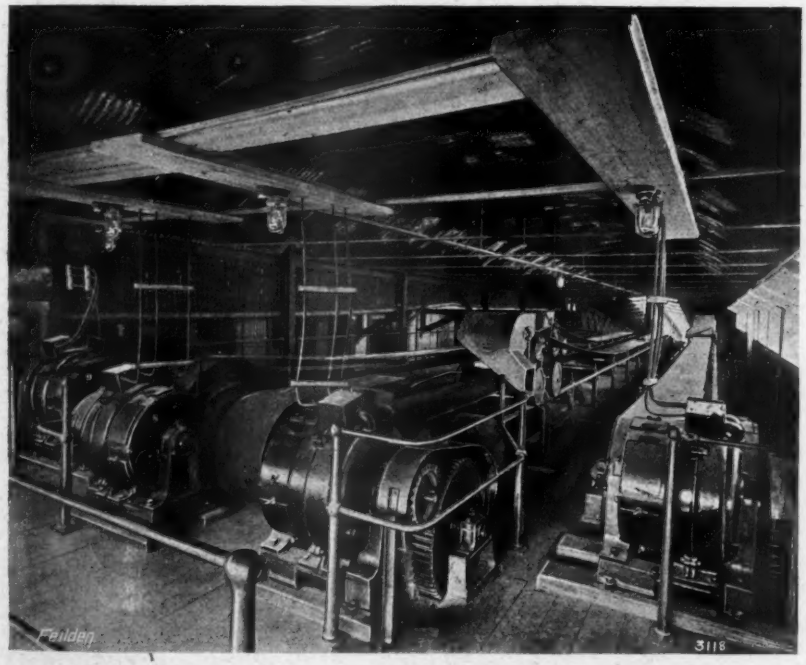
Our superiority in labour-saving machinery in gas works over America is particularly marked, and most frankly admitted by managers of American gasworks, many of whom have visited England recently to study the improvements. Within the last few years the system of setting retorts on the incline has been adopted at numerous gasworks in England, with such success as relieves the stokers from the severe and hot labour of shovelling the coal into the retorts, and at the same time reduces the cost of carbonising coal over 50 per cent. In this new method the retorts are set at an angle of about 32 degs from the horizontal, and the law of gravitation is utilised to automatically trim the charge of coal, in an even layer on the retort floor. In this almost labourless system of charging gas-retorts, the coal, as it is brought to the works by wagon, barge, or ship, is lifted by a bucket elevator to a coal hopper fixed over the bench of retorts, and along the bottom of this hopper measures on the "shot-pouch" principle with cut-offs and the charge of coal in the measure falls

through a shoot down and all over the floor of the retort. A distinguished American engineer, who recently inspected this "shot-pouch" method of charging inclined retorts in England, wrote:—"This 'shot-pouch' system leaves me in no doubt about having established the right to be preferred over all other methods of charging gas-retorts." Any system but the "shot-pouch" is only half-way automatic in a retort house. The "shot-pouch" method of putting the charge of coal into retorts set at an incline of 33 degs. has reduced the cost per ton of coal carbonised, in English gasworks, from 3*s.* to 1*s.* 3*d.* The cost in America is 4*s.* to 5*s.* per ton. I anticipate, however, a wide adoption of the "shot-pouch" system in America, and it is safe to predict when the inclined retort system, now largely adopted in England, has been copied by American gas engineers, the English daily newspapers will contain many articles about this American (?) invention. Equally efficient automatic coal-handling plants have been erected at electric light and power generating works—one in particular at the McDonald Road station in Edinburgh, to the designs of Professor Kennedy, is as thoroughly self-acting as human or even American ingenuity could devise.

IRON AND STEEL WORKS.

In our iron and steel works, where coal is consumed in huge quantities, labour-saving devices have not been so generally adopted as in gasworks, but this applies only to a few districts, as some of the steel works in the North of England and Scotland are equipped in the most efficient manner with automatic conveyors and elevators to distribute the coal to and remove the ashes from ranges of gas-producers and batteries of steam boilers.

A few months ago I had the pleasure of conducting a gentleman connected with Carnegie's great steel works, at Pittsburg, over several British works, and he unhesitatingly admitted the automatic coal-handling



LONG BAND CONVEYORS DRIVEN BY ELECTRIC MOTORS, AT THE AVONMOUTH DOCKS; CONSTRUCTED BY MESSRS. SPENCER AND CO., MELKSHAM, WILTS.

plant in operation at modern steel works near Glasgow was in every way superior to anything he had seen in America. Let me describe the system in use at some Glasgow steel works to deal automatically with coal in support of my statement that America is not ahead of us in the use of labour-saving coal-handling machinery in the greatest coal-consuming works of both countries, steel and gas works. In the most modern steel works the coal wagons are brought over a receiving hopper, where hydraulic rams are put in motion, which raise and empty the coal in the wagons into the hopper. Two wagons, each holding 10 tons of coal, can be emptied in four minutes. In the bottom of the hopper a conveyor is fitted, which carries the coal to a large bucket elevator. This elevator lifts the coal to a height of 50 ft. and delivers it into several rows of conveyors, which distribute it into the feeding hoppers of ranges of gas-producers. My American friend frankly admitted they had no such efficient and economical labour-saving machinery at any steel works in America. Equally complete systems of automatic coal- and ash-conveying machinery are in operation all over England—at cement works, chemical factories, dye works, cotton and wool mills—and British engineers believe it is only "budding novelists" on some daily newspapers who can be responsible for the oft-repeated and silly statements about "American labour-saving devices being far ahead of British."

In the foregoing remarks I have dealt with the manufacturing side of the industrial war, and I now turn to the social, and the part employers and employed play therein, on both sides of the Atlantic. First the employers. Not long ago *The Times* sent out a special commissioner to report on and contrast American methods of manufacture with British. He gave us some lucid pen-portraits of American employers and workmen, and assured us there is no leisured class in America. From sunrise till sundown the American employer goes at his only object in life—the making of money, and when he gets it he has little idea of what to do with it, except to finance a "combine," or a son-in-law duke. Is this feverish struggle of a hundred American employers to "make a pile" likely to build

GANTRY BAND CONVEYORS AT THE AVONMOUTH DOCKS, BY MESSRS. SPENCER AND CO., MELKSHAM, WILTS.

up a great and stable country? I trow not. These men sacrifice everything to the "almighty dollar" and accuse us of being a lazy, sport-loving race; still, lazy men are not good raw material for a nation of athletes. That by the way. American industrial industriousness is confined to a few manufacturing centres like Chicago, Pittsburg, and New York, and a hundred enormously rich men, in a population of a hundred millions does not spell peace and contentment for the future, or a solid and lasting advance for a vast population; so, after all, I may not be wrong in stating I consider the air of importance assumed by many American manufacturers is their characteristic credential of impotence, and still more so of the ill-informed British pressmen, who bespatter them with unmerited praise. Perhaps the object of these writers in decrying British engineers is to remind us the way to feel safe is never to feel secure; still, they might credit us with knowing something of our profession, and not of being entirely ignorant. These journalists may have persuaded Americans that the industrial race is to the swift; we believe the battle is to the strong. British engineers are not War Office officials, and we feel far from danger, because we are on our guard and prepared even when in safety.

SHIP ELEVATOR AT THE AVONMOUTH DOCKS, HOUSED POSITION, BY MESSRS. SPENCER AND CO., MELKSHAM, WILTS.

The hasty conclusions of British non-technical editors against manufacturers, let us hope, may lead to speedy and sincere repentance, and to an expression that it will be a bad day for the Motherland of the British Empire when the wealth is in the hands of a hundred multi-millionaires who combine to hustle labour to the wall and "hurl" everything out of their money-making path except an English lord.

Memory gilds the past of British engineering, why should Hope not brighten the centuries to come? In spite of the hundreds of articles by British writers belittling British enterprise trade has been good, employment abundant, money cheap and widespread. So away with gloom, the British engineer's lack of rashness is evidence that experience has taught him to take heed lest he stumble. He is not of the race of mortals who become old in their youth and die ere middle age, *Consilium senum est sanum.*

In the hardest days of the Chosen People, when the tale of bricks was doubled, Moses made his appearance.

There are not bulrushes enough in America to hide the needful "deliverers of the people," strenuous men like Moses, to emancipate American workers from the sway of American Pharaohs, the multi-millionaires.

Our American and German rivals shall see our Waterloo in the industrial war when mules breed.

So far back as 1840 Lord Macaulay wrote :—

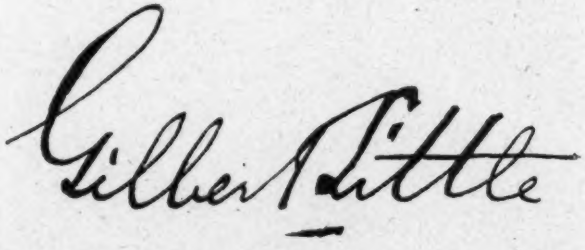
"Ever since I began to make observations on the state of my country, I have seen nothing but growth and heard of nothing but decay. The more I contemplate our noble institutions the more convinced I am that they are sound at heart, that they have nothing of age but its dignity, and that their strength is still the strength of youth."

That is infinitely more characteristic of British industries to-day than in 1840, when Macaulay penned these beautiful words. In England we all recognise that the problem which industrial progress has to solve is how the greatest number of persons can live with the least labour, in the greatest possible comfort, and how persons and general affluence may increase and labour decrease in quantity. That is the dominant idea among employers and trade-union leaders in England, and it is quite left out of the thoughts of Americans in every station in life.

"Great boast" by American advertisers spells "small roast" for the unskilled labouring classes in the United States, and British manufacturers can cheerfully say to their American pupils :—

"Friends, for your bouncing style I'm grieved,
In which so much is said;
One-half will never be believed,
The other never read."

I cannot imagine the heterogenous working classes of America acting homogeneously for an increase of wages, to obtain a better share of the money that creates multi-millionaires. The lion may lie down with the lamb, but the combining of Turkish and Greek, German and French, American and Russian, Italian and Swedish, Polish and Hungarian workmen in trades unions, is impossible, therefore these variegated workers, helpless because so various, will for some time to come be the American employers' best hope against strikes. Work these people must have; and in all the American States these men work ten and twelve hours a day. Here it may be thought we are at a disadvantage; I do not think so. Good, honest workmen turn out more work in nine hours than in twelve, year in and year out, and work and alternating enjoyment are the two human functions necessary to the healthy life enjoyed by our working classes. It cannot be denied, while the enjoyments of the capitalists have undergone surprisingly few changes through additions to objects of desire obtainable through labour-saving, machine-created abundance, the British working classes toil and spin less weary hours, and participate in many luxuries formerly within the reach only of the wealthy few. This is as it should be. Improved and free education is rapidly raising the entire population above the condition of unskilled labourers. The great race of British inventors, luckily for populous England, preceded the day of compulsory education, otherwise our educated population would be doing shovel and wheelbarrow work now accomplished by automatic machinery. This spread of education in England is bringing about the disappearance of distrust at the wider application of labour-saving machinery. Education is levelling intelligence, and aided by the largely increasing number of the working classes attaining the highest positions in art, science, and commerce, Britons will, despite the shorter working hours and greater enjoyments of their workers, at least hold their own in the industrial way.



WORKSHOP PRACTICE

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

Centering.—To place a centre dot exactly at the intersection of two lines, the sense of touch may with great advantage be made use of in the following way. Put the point of the centre punch in one of the scribed lines, and, holding lightly, move it along until the other line is reached; this point will be shown by a slightly deeper depression in the metal, which can be distinctly felt after a little practice.

H. HELFRITSCH.

Grinding of Tools.—When grinding turning tools it is often found that there is a tendency to overheating; and, as this will soften, and may cause the tool to crack, it is essential that it should be avoided. If, instead of putting the tool flat on the grindstone, the heel be first applied, the water will keep the point of the tool cool; and when the bulk of the metal is removed, the point may be ground with less pressure and less risk of its getting hot.

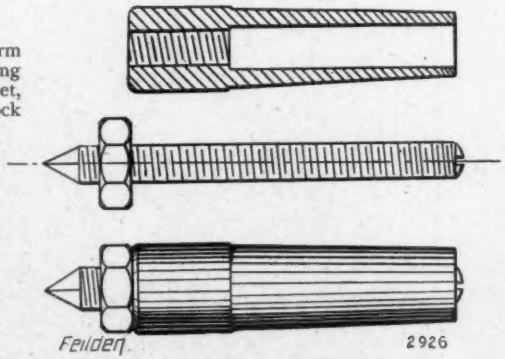
H. HELFRITSCH.

A Square Centre.—A very convenient form of square centre is shown herewith, consisting of a Bessemer steel hollow stump or socket, fitting the taper of the loose headstock spindle, and provided about one-third of its distance up with an internal thread the remaining portion of the hole being bored about $\frac{1}{16}$ in. larger than the bottom diameter of same. A cast steel screw of good fit is kept in position as shown by a lock nut against the socket end. The claim for this form of centre is a considerable saving of material over the solid form of cast steel centre—where numbers of turners are employed—and the long life of the working part.

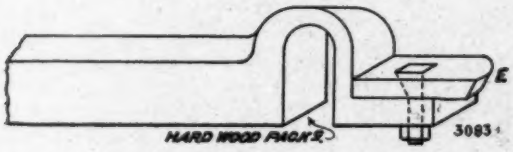
T. SMITH.

Trouble with Dynamo Brushes.—A short time ago a great deal of trouble was caused by the brushes of a dynamo becoming saturated with oil. The brushes were of the ordinary wire gauze type, and after running an hour or two, the dynamo, which was driven by a gas engine and used for lighting purposes, had to be stopped and fresh brushes put in, the others being taken away and dried. After trying various means for preventing this, the trouble was finally traced to the commutator, the hole through which was found to be slightly larger than the spindle. The oil crept along the spindle and then worked up between the segments of the commutator on to the surface, and was then scraped off by the brushes. The hole was caulked up all round, and after the dynamo had run a short time to drive off the oil already in the commutator, there was no further recurrence of the trouble.

J. E. L.



A SQUARE CENTRE.



SPRING TURNING TOOLS.

Spring Turning Tools.—Spring turning tools used for water finished work are mostly used with rounded corners, as the majority of jobs for which they are suited finish with a radius in the stepping from one diameter to another, as in crank shafts, bowl necks, journals, &c. A considerable amount of trouble is experienced at times, when the alteration of radius is necessary, especially where a return to the original is required. An arrangement as shown overcomes the difficulty, by having cutters with varying sized corners and which may be fixed and held in position on the front of the spring tool by means of a wedge bolt as shown. The loose cutters are of tool steel, about $\frac{5}{8}$-in. thick, milled to the required form and backed-off, slotted for bolt, then hardened and afterwards ground. Thus rounds and hollows may be finished alternately, on the same piece of work, by substituting different cutters without removing the holder. A further saving is in the cost incurred in altering a tool made in one piece, viz., the drawing out, grinding, and hardening. W. F.

[The cutters must be of uniform thickness in order that the height of the cutting edge *E* will be in exact alignment with the centre of the work.—ED.]

Adjustable Support.—The use of a serrated wedge as an accessory to an adjustable support is shown at Fig. 1. The ordinary L-shape bracket provided with a central slot is used as a base to which different forms and widths of packing pieces may be clamped. The several packings are made of cast-iron, with a corresponding slot, and the use of the wedge is to assist in preventing the tendency of the packing to slide or set down when pressure is applied on top, as in the use of the bolt *B* (Fig. 2), which shows the support in use on a planer table. A section of the wedge is shown on the right of Fig. 2.

W. F.

FIG. 2

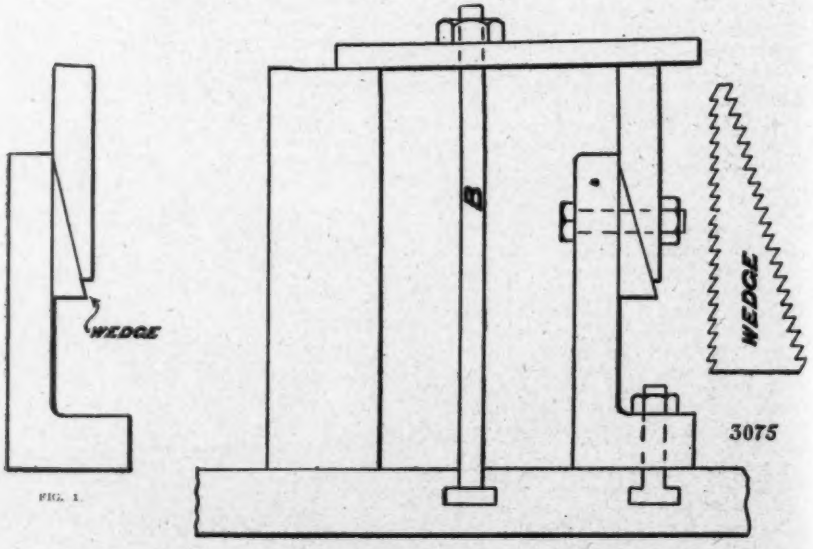
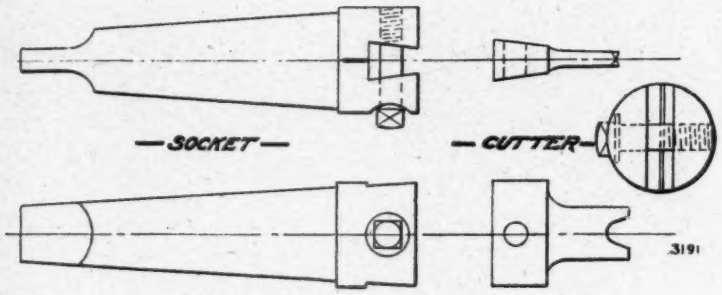


FIG. 1.

ADJUSTABLE SUPPORT.



SLOT DRILL SOCKET.

Slot-Drill Socket for Interchangeable Cutters.—This socket was made to accommodate a series of cutters in a slot-drill, and fulfilled all the requirements needed. It is turned taper to fit drill spindle and left parallel at the bottom for about 1¾ in. up, and drilled and tapped to receive a set screw which passes right through the bottom diameter. It is then milled out to dovetail, as shown, and in order to increase the grip of the screw on the cutter, a saw cut is made towards the shank end about 1½ in. deep. With this auxiliary a full range of different size cutters, from ⅜ in. up to 2 ins., will fit one socket, but the cutters should not project out of the socket more than 2 ins. to be rigid, and therefore cannot be used on cotter holes above that depth. The style of cutters used are shown in the sketch; they should be ground out in the centre with a sharp cutting edge left on each side about ¼ in. to ⅜ in. wide, according to their size.

Twist-Drill Socket for Lathe Work.—This little appliance is intended to hold twist drills in the slide-rest of a lathe. It is made out of a piece of square steel, any length from 12 ins. to 18 ins., to suit requirements, and bored out at each end to a Morse taper to hold a twist-drill or socket. Two cotter holes should be cut in, as shown in the sketch, to allow the drills to be wedged out, as in an ordinary drilling machine. The bar is turned about 1 in. up at each end to enable it to be run in a steady rest, whilst the taper holes are being bored in the ends. Great care should be taken when in use to set each end exactly central with the lathe centres, or else the drill will choke or stick fast, being parallel all the way up. Much time is saved by this appliance, instead of having to wait for common drills being forged, hardened, etc., and the advantage of using the more freely cutting twist-drills. (£1 1s.) J. GREEN.

A Recipe for Cooling an Overheated Bearing.—A few weeks ago the main bearing of our works engine became very hot, and the engineer adopted the same tactics as described in your September issue, viz., poured a bucketful of water over it. This had the desired effect, and we continued running; but it had cracked the brasses, as we found out a few days afterwards when re-heating took place. At this time—in the absence of the engineer—I was in charge of the engine, and instead of using water I thought of a recipe given me some years ago, and which may be useful to some of our readers who are similarly fixed. It is composed of the following ingredients:

2 parts by weight of tallow
1 part „ „ white lead

The tallow is melted and the white lead well stirred into it; it is then reduced to the consistency of cream by the addition of some good cylinder oil. This mixture was gradually poured on until the bearing was cool, afterwards lubricating with ordinary engine oil. "COOL BEARING."

TWIST DRILL SOCKET.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

Electrical Transmission in Collieries.—Messrs. Scott & Mountain, who have for many years made a specialty of the equipment of mines, inform us that they have recently secured an important contract from the Broughton and Plas Power Coal Co., near Wrexham, for an important extension of the installation that they supplied some time since for the Plas Power Colliery. This extension plant, which has been at once taken in hand, consists of one of the firm's two-crank enclosed compound self-lubricating engines of 350 h.p. coupled direct to one of its 200 kilo-watts six-pole dynamos of the continuous-current type, and the new plant will supply current to the Gatewen Colliery, about 2,000 yards from the generating station, for driving the underground haulage gear there, which is a distance of about one mile in length, the motor for driving this gear being of 200 h.p. The company's object in adopting electrical machinery has been to concentrate the whole of the power in one central station at Plas Power, and distribute current to the various collieries for driving pumps, haulage, gears, etc.; and the extremely satisfactory results of the first plant has induced them to make extension as described above. We also understand that Messrs. Scott & Mountain have obtained a very important pumping contract from the Ashington Coal Company for their Woodhorn Colliery, referring to a plant consisting of one of the firm's multipolar continuous-current dynamos of 270 electrical horse-power, driven by a horizontal long-stroke compound engine. This generator will supply current to four electric motors, each driving three-throw ram pumps, also of Scott & Mountain's manufacture, the first set of pumps being for main-shaft pumping, and delivering 400 gals. per minute against a head of 600 ft., the second set of shaft pumps delivering 150 gals. per minute against a 350-ft. head, and the two smaller pumps for dip workings, each delivering 100 gals. per minute against a head of 100 ft. The same firm are also supplying the complete electrical generating plant for Messrs. Pease & Partners' Bankfoot Colliery, Crook, for driving coal-cutting machines, etc., consisting of a long-stroke compound engine of 350 h.p., and the generating dynamo is capable of giving an output of 270 electrical horse-power at the terminals. The large pumping plant which the same firm have had in hand for the South Durham Coal Company, Bishop Auckland, is now nearing completion. This plant consists of a horizontal long-stroke compound engine of 450 h.p., driving a 250 kilo-watt generator, which supplies current to two sets of main shaft pumps, each pump delivering 500 gals. per minute against a head of 400 ft., or collectively 1,000 gals. of water per minute, and each pump is driven by an electric motor of 120 h.p.

Aluminium Unalloyed.—Professor Wilson's paper read before the British Association, and the discussion following, clearly established that whatever may be said of aluminium combined with other metals, unalloyed it has disappointed nearly all the expectations based on the discovery of a cheap method of its production. Our contemporary the *Journal of Gas Lighting* gives the following very lucid digest of Professor Wilson's paper: "Aluminium," said Professor Wilson, "does not exist uncombined in the metallic state, being essentially a product of chemical industry. Aluminium can be used to produce an enormous number of alloys, some of which, containing 1 to 2 per cent. of other metals, combine the lightness of aluminium with greater hardness and strength. On the other end of the scale, alloys containing from 90 to 99 per cent. of other metals exhibit properties of those metals, but much improved for certain purposes. Unfortunately it is when aluminium is used alone that its chief recommendation—lightness—is found to be counterbalanced by other considerations. The efforts that have been made to use aluminium wire for telegraphs and telephones have not been very encouraging, owing to the uncertain texture and weakness of the drawn wire. The same difficulty occurs with tubes and sheets of the metal. No guarantee of strength can be obtained from the manufacturers short of thicknesses far in excess of what would be required of copper and still harder and tougher alloys. There is consequently no advantage in using the lighter but more uncertain and costly metal. The chief advantage of commercial aluminium appears to be for the construction of cooking utensils. A great difficulty is found in soldering the metal; and it will not stand salt water. On the whole, therefore, aluminium must be classified by practical men as a disappointing metal.

Acetylene Black.—Calico printers are beginning to realise the value of one of the most useful properties of acetylene—namely its agency in the production of the present "lamp-black," entirely free from gritty particles. The method of producing this important colouring substance consists

in igniting acetylene in a closed vessel by means of an electric spark, which is possible because acetylene is self-burning and requires no oxygen. In this way a dense smoke is produced, consisting of the desired product. To produce "lamp-black" for commercial purposes the process, as our contemporary the *Journal of Gas Lighting* remarks, requires the following precautions: "A gas-tight vessel is exhausted of air, and filled with acetylene to a pressure of 2 atmospheres. The charge is then decomposed, either by spark or a hot wire, when every cubic metre of the gas yields the same volume of hydrogen and 1 kilogramme of the black. The latter is 99·8 per cent. pure carbon. It is very soft and light; can be made into a paste with water after being allowed to soak in it for some little time; and is miscible in all proportions with oils, gums, gelatine, and other vehicles of black pigment. Diluted with a suitable solution, as albumin, it will give any desired shade of grey, being remarkably intense and equal in quality. This unexpected application of acetylene appears likely to grow in importance, and possibly to keep the factories going. It is interesting to remark that this use of acetylene has sprung into existence since the publication, in 1900, of Lewes's work on acetylene."

High-Speed Electric Railways.—The experiments recently inaugurated on the military railway line from Berlin to Zossen, with the object of studying the problem of high-speed locomotion on railway tracks by using electricity as a motive power, have been temporarily suspended. The *Elektrotechnische Zeitschrift*, however, publishes a communication giving at first hand the history of the trials and the results obtained so far, from which we gather the following data, which, we believe, will interest many of our readers. The experiments were begun early in September last, and the two express-cars which were to be used during the trials were first drawn up and down the line by an ordinary locomotive to get them into good working order, and to discover any defects in their construction before taking them into service. After these preliminaries the actual tests were started with a speed of 60 km. per hour, which was gradually increased to 100, 120, and 140 km., the highest speed so far obtained being 160 km. (99·4 miles) per hour, for which a pressure of above 10,000 volts was maintained in the supply wires. The highest speed so far obtained with steam-engines amounted to 130 km. (80 miles) on European railway lines, and to 140 km. (87 miles) on lines in the United States. The experimenters report that, on the whole, the trials were very successful, the practical results obtained consisting in the collection of important data referring to the most suitable starting speed, the stopping of high-speed trains by means of brakes, the visibility of signals, the consumption of power, the resistance of the air, and many other points of importance. It was further shown that the conductors, the devices for taking off the current, the electrical apparatus, and the cars themselves have so stood the tests that, as far as the rolling stock is concerned, the speed so far obtained may be safely increased to a considerable extent. The only weak point discovered so far, we are informed, has been the permanent way, and it has been decided to strengthen it before making further tests, which explains the temporary suspension of the experiments.

British Push.—Our Midlands representative has lately come across a notable instance of push and energy on the part of a British firm, which is quite refreshing to hear about in these days of so-called decadence, &c. Messrs. Gent & Co., of Leicester, electricians, on the night of 17th-18th December, had their entire works burnt down and completely gutted, and the greater part of both plant and stock destroyed. Despite the fact that the principals were in London at the time the firm had, within 16 hours of the receipt of telegram *re* out-break, signed a lease for a large new factory, fortunately vacant, covering over half an acre, bought a new engine and boiler, and started to instal machinery in the new premises. What is still more creditable, they were actually able to start work again in their new premises within 48 hours. When one realises that Messrs. Gent's factory is a large one filled with many delicate tools, one cannot help admiring the resourcefulness and energy displayed. Everything is now in full swing in their factory, and they are open to execute all the orders that may be offered.

Electricity and Gas Combined.—We gather the following from a paper on "Practical Power Transmission," recently read before the Pacific Coast Gas Association by Mr. Martin, and published in the *Journal of Electricity*. After having pointed out that there are distinct limitations to the utilisation of water-power, especially on the Pacific Coast, owing to the great difference in the volume of water available in different seasons of the year, Mr. Martin dwells on the advantages to be derived from combining electrical supply stations with gas-works. This, of course, is not a new suggestion; but to many the hint will be valuable that when gas-plants and electrical transmission are to be combined, it will be more economical to buy the current, where obtainable, even at a cost of from 15 to 20 per cent., than to manufacture it locally, for the reason that the capital which would be required in building a generating station will give better returns when used in developing an electric distribution system. In making this statement Mr. Martin can claim to speak from experience, for it appears that he has obtained by this method considerable success in the plant he manages. Speaking of his plant in Marysville he affirms that the electric enterprise yields more profit than the gas-works; first, because it has not to carry the cost of a generating plant; and, secondly, because he recommends gas not for lighting but for fuel purposes, though he does his best, of course, to render it profitable in this capacity. It is also interesting to learn that he has found "flat rates" the most suitable for popularising electric lighting, his charges being one dollar a month for a three or four-room house,

and that he in this way receives more money per "block of ground" than from customers living in the better residence districts.

Uganda Bridge Contracts.—The report that the United States have secured the British Government contract for steel bridges for Uganda, has, as the Wolverhampton correspondent of the *Yorkshire Post* announces, caused both surprise and great indignation. Nearly all the South Staffordshire steel bridge builders tendered for portions of the work, which is worth altogether about £200,000. The British firms declared that their tenders were cut very fine, being based on the following low estimates for material: bridge plates, £7 5*s*.; bridge girders, £6 5*s*.

It is always interesting to know the progress being made with electric light, and the extent to which managers of power stations avail themselves of the automatic labour-saving appliances. The New Conveyor Co., Ltd., of Smethwick, have received a very large contract from the Leeds Electric Lighting Department, which will enable coal to be taken out of boats and put into stoker-hoppers without any hand labour, and the ashes will be removed on a hot coke conveyor, which puts them right into carts, also without any hand labour. We hope to be able to publish full details of this installation in a future issue.

Discovery in Steel-Making.—It is stated that a new process of steel-making has been discovered by Herr David Giebler, of Grabon, in Mecklenburg. By this process, it is alleged, steel of a hardness twice that of Krupp or Harvey steel can be produced at half the cost of the latter. Projectiles shot against a 7⅞-mm. armour-plate made by the Giebler process produced but a dent 1 mm. in depth, while Krupp steel armour of 11¾ mm. was entirely perforated by the same projectile at the same distance. It is added that with sword blades made of the new steel ordinary steel blades were shivered into splinters as if they were made of wood.

American Engines *v.* British Engines.—In order to settle the dispute as to whether American locomotives seriously compete with British locomotives abroad, it will suffice to glance at the record of their output and export recently published at request by Messrs. Burnham Williams & Co., of Philadelphia, the builders of the famous Baldwin locomotives. In 1896 they built 547 locomotives, exporting 289; in 1897 they built 501, and exported 205; in 1898 they built 755, and exported 348; in 1899 they built 901, and exported 375; and last year they built 1,217, of which they exported 363. Comments are unnecessary.

Standardisation of High Pressure Steam Pipes.—The fixing of standard dimensions of steam-piping has been under the consideration of a committee of the Society of German Engineers for many years, and only quite recently a conclusion was reached which enabled them to propose definite standards for acceptance. These standards have reference to pipes of from 30 mm. to 400 mm. (1·18 ins. to 1·57 ins.) diameter, and for working pressures of eight to twenty atmospheres (113·6 lbs. to 284·4 lbs. per sq. in). For pipes of over 300 mm. (11·8 ins.) diameter, a set of dimensions for 15 atmospheres (213·3 lbs. per sq. in.) pressure has also been worked out. Cast iron is permissible for all sizes of pipes when the pressure is not greater than eight atmospheres, for pipes up to 150 mm. (6 ins.) when the pressure is between eight and thirteen atmospheres, and not at all above this pressure. When wrought iron or steel is used for the pipes, the walls are not to be subjected to a greater stress than 400 kgs. per sq. cm. (2·54 tons per sq. in.).

Novel Use for Trolley.—An interesting suggestion has recently been made by the chief of the fire department at Rouen, namely, that of utilising the presence of trolley wires in so many parts of the city for the purpose of obtaining the force required for driving the pumps of fire-engines in case a conflagration occurs near any of the electric tram lines. The fire-engines, in his opinion, might be fitted with electric motors instead of steam engines, and connection will be made to the trolley wire or to the trolley feeder in the immediate neighbourhood of the burning building. The arrangement should save valuable time, especially during that important first fifteen minutes, since there will not be even the necessity of getting steam up from banked fires. If also the connection to the electric tramway service is made at one of the feeder pillars, as can easily be done, the tramway service should not be interfered with.

A Simplified Rotary Engine.—The number and variety of forms of rotary engines seems well-nigh inexhaustible, but those that are most simple in design and execution naturally deserve our chief attention. Fewer of them hitherto placed on the market are more simple and compact than a rotary engine invented by Major J. Robinson, of Los Angelos, in Southern California, and described in a recent issue of the *American Machinist*, from which we take the following data. This engine consists mainly of a thick disc, having a long trunnion, and in the face of this disc, at one side near the periphery, is formed a cylinder with trunk piston, which is connected by a rod to a fixed point in the bed-plate, the connecting rod having ball joints at each end. The trunk piston moves to and fro by steam admission through the trunnion, and in doing so of course causes the disc to revolve. It is easy to see by the drawing how the device works. When the piston part of the disc is down, the piston itself is thrust to the bottom of the cylinder. There steam is admitted behind the piston, and the disc revolves to the upper position, when, the stroke being completed, the steam is released, and the momentum of the disc carries it round to the starting position. And so on it keeps going. The admission of the steam

may be so controlled as to be used expansively, which is a feature not often found in a rotary engine. But this may be called a combination of a reciprocatory with a rotary movement.

Growth of Japanese Shipping.—The wonderful progress in industrial enterprise which astonished the Western World when it first became known continues unabated, and is well represented in the official data regarding the recent increase in tonnage in the highly subsidised shipping of that country. In 1883 entries of Japanese vessels were so insignificant that they were not considered worthy of the slightest notice in the Consular reports. In 1900 they amounted in number to over 3,000 vessels, of nearly 3,500,000 tons; and while in 1891 only 10 per cent. of the total imports and exports was borne in Japanese ships, in 1900, out of a total export and import trade of 480,000,000 yen, the value of that carried in Japanese bottoms was over 148,000,000 yen. In 1872 Japan possessed 96 merchant steamers, of an aggregate tonnage of 23,364 tons. In 1900 her merchant fleet included 846 steamers of 528,321 tons, most of them vessels of the highest types of modern construction.

The Value of Superheaters.—Among the Foreign Abstracts in the Proceedings of the Institute of Civil Engineers, we find the following data, referring to the use of superheaters, which, we believe, will be of interest to our readers. The value of superheaters, says the author of the summary, depends mainly on the fact that by their use an increase is effected in the volume of the steam, and hence, also, in the work obtainable from it, while the expenditure of heat is increased to a proportionately smaller extent. In a table based on the increased volume of the steam, and showing the percentage saving of heat when working at various pressures and with various degrees of superheating, the figures obtained vary from 0·4 per cent. for a pressure of fourteen atmospheres, and a temperature of superheating of 200 deg. C. up to 27·9 per cent. for a pressure of four atmospheres, and a temperature of 440 deg. C. do not, however, agree with those actually yielded in practical working, owing to several secondary actions, some of which increase while others diminish the calculated saving. One of the most important of such secondary influences is the degree of supersaturation of, or amount of water contained in, the steam, the condensation of this water on the cylinder walls and the consequent dissipation of heat being obviated by superheating. Further, the saving in fuel is not so great as the saving of heat due to the superheater, since such circumstances as the imperfect using of the fuel and the walling-in of the superheater here come into play. With regard to the latter point, in the case of water-tube boilers there is a space directly above the tube system suitable for receiving the superheater, and to this, and also to the fact that water-tube boilers often produce much wetter steam than is the case with Cornish boilers, is due the greater success of the superheater when used in conjunction with the water-tube boiler. The construction of superheaters, the guiding principle of which is to obtain the largest possible heating surface compressed into a minimum of space, has followed mainly two principal forms, the older one being the cast-iron ribbed superheater, while the more modern pattern consists of narrow wrought-iron tubes. When possible, it is undoubtedly preferable to arrange the superheater in a vertical position, in which it is less liable to collect ashes and soot, which are besides more readily cleared away. The methods of regulating the temperature of superheating are also treated of.

British *v.* American Locomotives.—A recent issue of *The Engineer* contains a very interesting contribution by M. Charles Rous-Marten, in which he makes use of a time-honoured rule of debate, and replies to the criticisms which his views, expressed in an article bearing the same heading in the same journal, published June 14th last year, had received during a very extended discussion caused by their enunciation. If it is borne in mind that M. Rous-Marten had an opportunity of becoming acquainted with almost every objection that could be raised against his opinions, most of our readers, we are sure, will be glad to learn that so high an authority still adheres to his favourable opinion regarding locomotives built in this country. In his concluding remarks he makes the noteworthy statement that if the issue raised by his article had been the question of American *versus* British practice—which it was not—all he could say was that, although he preferred almost every point in the British method, he could not but assume that the Americans may have good reasons in local conditions for selecting the method they have selected. "But I must insist"—these are his own words—"on again expressing the conviction, which I declared in my previous article, that, comparing engine with engine on the basis of efficiency per unit of nominal power—reckoning the capacity of the boiler and fire-box as well as of cylinders and wheels—and also on the basis of performance per unit of nominal power, no locomotive exists in the world that is superior to the British."

Arbitrary Steamship Freight Rates.—There can be no doubt that a good deal of the recent success of our foreign competitors is due to our own doings. A correspondent in Shanghai writes to a well-known firm of manufacturers of fire-clay goods in this country: "In an invoice for fire-clay goods valued £700, the freight charges, etc., if from Great Britain, amount to £1,100, whereas if obtained from the United States of America they would be £600, and if from Japan £100. This is, on the whole, a good example of the way in which the arbitrary fixing of rates by steamship company conferences interferes with British trade."

Accumulators for Automotor Vehicles.—A well-known technical journal published in Germany, the *Centralblatt für Accumulatoren und*

Elementenkunde, devoted to the subject of primary and secondary batteries, gives, in two consecutive issues, a detailed account of the leading types of accumulators used in the United States in connection with motor vehicles. The main data of this interesting contribution have been summarised by our esteemed contemporary *The Electrician*, and, as a further condensation would deprive the information contained in this digest of much of its usefulness, we give it below *in extenso*:—

The Sperry Accumulator Cell.—A battery of 44 of these cells gave a current of 40 ampères at a mean discharge e.m.f. of 1·975 volts for 5¼ hours. Each cell weighed 10·5 kg. A battery which had covered 12,300 km. in a motor vehicle lost only 28 per cent. of its original capacity; and tests by Langley showed that this battery up to the point when 4,900 km. had been covered was yielding 2·2 ampères per kilogramme of weight.

The Clare Accumulator Cell.—Tests of a single Clare cell of 20 ampère-hours capacity, showed a fall from 2·1 to 1·72 volts during a 10-hour discharge at 2·2 ampères. Yielding a current of 5 ampères for 3½ hours the same cell showed a drop from 2·1 to 1·66 volts. A cell weighing 7·2 kg. gave 12 ampères for 8 hours with an e.m.f. fall of only 0·20 volt, and yielded 26·67 watt-hours per kilogramme of weight.

The Perret Accumulator Cell.—A single Perret cell weighing 3·4 kg. during a 5-hour discharge at 10 ampères, showed a fall in potential of 0·50 volt. The capacity of this cell per kilogramme of weight was 28·08 watt-hours. The cell is made in two sizes, of 95 and 190 watt-hours' capacity respectively.

The Gould Accumulator Cell.—This cell is manufactured in various sizes, the weight of each cell ranging from 9 kg. to 30 kg., and the capacity for a 3-hour discharge ranging from 125 to 517 watt-hours. The cell yielded 7·33 ampère-hours, or 13·9 watt-hours per kilogramme of weight, for a 3-hour discharge. The fall in potential under these conditions is rapid, and amounts to 0·40 volt in 90 minutes. A cell containing seven plates weighed 14·8 kg., and had a capacity of 90 ampère-hours for a 3-hour discharge, and a capacity of 100 ampère-hours for a 4-hour discharge.

A Chloride Accumulator Cell.—The potential fall of this cell during a 3-hour discharge was 0·25 volt. The capacity per kilogramme of cell weight is, however, low, amounting only to 4·13 watt-hours. The new "Exide" cell of the same company is superior in this respect, as it yielded 16·87 watt-hours per kilogramme of weight. During a 4½-hour discharge the fall in potential of this cell amounted to 0·33 volt.

The Willard Accumulator Cell.—This cell is manufactured in various sizes, ranging from 6 kg. to 28 kg. in weight, and from 34 to 254 ampère-hours' capacity. During a 3-hour discharge the fall in potential of the "Standard" type of cell was 0·50 volt, and the capacity per kilogramme of cell weight worked out to 12·15 watt-hours. The "Special" type of cell under the same discharge conditions yielded 12·80 watt-hours per kilogramme of cell weight.

The Porter Accumulator Cell.—These cells are manufactured in various sizes, ranging from 3·8 kg. to 22·5 kg. in weight, and from 32 to 334 ampère-hours' capacity. A discharge test of the 5·7 kg. cell at 20 ampères during 3¼ hours showed a fall in potential of 0·50 volt, and the yield per kilogramme of cell weight was 21 watt-hours. The 11·2 kg. cell is said to yield 247 ampère-hours for a 6-ampère discharge rate, and the capacity per kilogramme of cell weight in this case works out to 42 watt-hours. A battery composed of these cells, and weighing 270 kg., has driven a light Stanhope carriage 300 km. on one charge, and a "Wood" travelling carriage has been driven 128 km. at a speed of 16 km. per hour, by a battery weighing 225 kg.

The American Accumulator Cell.—The weight of these cells ranges from 4·5 kg. to 32·5 kg., and the capacity from 5 to 72 ampères for 3 to 5 hours' discharge. The yield per kilogramme of weights for a 5 hours discharge therefore works out to 12·2 watt-hours.

The Reuterdahl Accumulator Cell.—A test of a single cell showed a fall in potential of 0·25 volt in a 3-hour discharge. The capacity of a 10-kg. cell under these conditions was 100 ampère-hours, and the yield was, therefore, 19·0 watt-hours per kilogramme of cell weight.

The Osburn Accumulator Cell.—The complete cell of this type weighed 6·75 kg. A test for a 4½-hour discharge showed a fall in potential of 0·40 volt, but for 2¾ hours the e.m.f. of the cell remained above 2 volts. The cell capacity for a 3-hour discharge was 79·5 ampères, and the yield per kilogramme of cell weight was, therefore, 23·3 watt-hours. A battery of these cells has been used to drive a motor vehicle 3,200 km. before any repairs were necessary to the cells or battery.

Trans-Australian Railway.—In a recent contribution to the *Engineer*, Mr. Stafford Ransome, M. Inst. C.E., discusses the many and varied advantages that the several parts of the Australian Commonwealth will derive from the realisation of the Trans-Australian Railway scheme. Up to the present the capital of Western Australia is entirely separated from the other capitals, and Western Australia, as far as communication with the other Australian Colonies is concerned, is practically an island, since the only access that Western Australians have hitherto had to the Eastern States has been by way of the ocean, while the time required for travelling from Perth to Adelaide, although the distance is only 1,300 miles, is almost equal to that required for passage from New York to Liverpool. That under these circumstances the development of Western Australia has been considerably retarded is easily explained, and that not only this portion of the Australian Federation, but also the Eastern States will be affected by reaction when, after the projected line comes into operation, the resources of the West can be properly developed is equally obvious. This, however, is but one out of many advantages that the building of the projected line will bring in train, some of which at this early date it would be impossible even to guess at.

THE WORLD'S INDUSTRIAL & ENGINEERING PRESS

In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

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THEORY.

Elasticity and Plasticity of Metals.—*The Non-Elastic Deformation of Copper Wire under Various Stresses.* By James S. Dunlop, B.A. (Cantab), M.A., B.Sc., Houldsworth Research Student at Glasgow. Description of an interesting series of experiments carried out by the author in Prof. Gray's Laboratory at Glasgow University with the object of determining the limits, if any, to the flow in certain wires under various loads. In the present case three specimens of commercial copper wire, taken from the same coil were used.—*Proceedings* of the *Philosophical Society of Glasgow*, Vol. xxxii., 1900-1901, p. 17.

Theory of Stratification Phenomena in Geissler Tubes.—*On the Theory of the Stratified Discharge in Geissler Tubes.* B. H. V. Gill, S.J., Clongowes Wood College, Co. Kildare. This is an amplification of the theory published by the author in an article contributed some time ago to the *American Journal of Science.* His theory is that the stratification is due to the certain mechanical disturbances caused in the body of the gas by the explosion of the spark and, further, that the experiments made by him establish the fact that there is a relation between the stratified discharge and the well-known experiment of Kunolt, and in which the position of nodes is shown by heaps of a light powder which are formed at certain places of the tube when the column of air inside is made to vibrate by some source of sound waves.—*Scientific Proceedings of the Royal Dublin Society*, Sept. 1901, pp. 715-21. (Ill.)

MEASURING INSTRUMENTS AND METHODS.

Measuring Oxygen in Solution.—*On a Simple and Accurate Method for Estimating the Dissolved Oxygen in Fresh Water, Sea Water, Sewage Effluents.* By Professor E. A. Letts, D.Sc., Ph.D., and R. F. Blake, F.I.S., F.C.S., Queen's College, Belfast. The authors point out that other volumetric processes had proved unsatisfactory and that as the amount of dissolved oxygen which water contains, either originally or which it looses in keeping—and especially the latter—is probably a more important criterion of what may be termed active pollution than any other, some simple and efficient determination, which can be used by the ordinary analyist, and, if necessary, at the place where the sample is collected, seemed to the authors to be a desideratum of importance. For this reason they have devised a method in which the simplest apparatus is used, as well as the most ordinary re-agents to be found in any chemical laboratory. In fact, many persons of ordinary intelligence, and without any chemical training, could be easily taught to perform it. It merely consists in absorbing the dissolved oxygen in a measured volume of the water by ferrous sulphate and excess of ammonia in a vessel completely filled with the three and closed both when mixing them and during the period necessary during the oxygen absorption. After this sulphuric acid is added in excess in such a way that no air gets admission during the process, after which the mixture is transferred to an open dish and then titrated either with permanganate or bichromate. These operations are described in all their details. *Scientific Proceedings, Royal Dublin Society*, Sept., 1901, pp. 457-471.

Meter for Magnetic Qualities.—*A Permeater for Testing the Magnetic Qualities of Materials in Bulk.* By Charles V. Drysdale. This is the republication of a paper read by the author before the Institution of Electrical Engineers, in which the author describes a permeameter constructed by him for testing the magnetic qualities of materials, especially iron or steel, for engineering purposes.—*Electrician*, Dec. 6th, 1901, pp. 267-72. (Ill.)

ENGINES AND MECHANICAL DEVICES.

1. Steam Engines and Accessories.

(a) Stationary Engines, Portable Engines, and Locomotives.

Locomotives.—*Consolidation Freight Locomotive: Canadian Pacific Railway.* This refers to one of the new engines recently added to the rolling stock of the line. Its weight is 159,500 lbs., the weight on the drivers being 140,500 lbs., and on the truck 19,000 lbs. The weight of the tender is 114,000 lbs., making a total weight of engine and tender 273,000 lbs.—*Railway Master Mechanic*, Dec., 1901, pp.386 387. (Ill.)

(b) Accessories: Boilers, Fuel Conveyors, Lubricators, etc.

Steam Generators.—*A Novel Steam Generator.* Description of a steam generator invented by Mr. Henry Braby, of Ayr, North Queensland, representing various new features of considerable interest, and its inventor claims for it the following advantages:—It occupies small space, about one-tenth of that of a multi-tubular boiler of equal power, its weight being but one-fourth of such a boiler when filled; it cannot be exploded, there being no large storage of water under pressure, and priming is impossible; it is self-cleaning; its life is practically unlimited; steam may be very rapidly raised, not more than ten minutes being required for a steam generator of 100 h.-p. and over.—*Engineer*, Dec. 13th, 1901. (Ill.)

Water-Tube Boilers.—*Water-Tube Boilers constructed by Mr. George Sims, Engineer, of Leith.* Description of a boiler, one of the chief features of which is the angle at which the tubes are set, so as to afford something like a combustion chamber.—*Engineering*, Dec. 20th, 1901, p. 849. (Ill.)

2. Air, Gas, and other Heat Engines.

Oil Motors.—*The International Kerosene Oil Motor.* Description of a motor invented by Mr. H. G. Underwood and manufactured by the International Power Vehicle Company, of Stamford, California, which, if the data given are supported by actual test must have a promising future, for automobiles, etc., as kerosene, is obtainable almost everywhere, and the motor requires no electric spark for ignition, which it will be granted is an important improvement. It is constructed on the two-cycle type, and all valves are dispensed with by employing the piston to open and close the exhaust and inlet ports in the usual manner. A 2½-h.p. motor, constructed by the above company, can be run all day for 25 cents.—*Scientific American*, Dec. 21st, p. 408. (Ill.)

3. Hydraulic Machinery.

Hydraulic Power.—*Hydraulic Oil Presses.* The original Burmah hydrostatic press has received applications in almost every industry of late years. The above heading refers to the adoption of hydrostatic power for the extraction of oil out of seeds, and the pressing of oil cakes. The present instalment of the contribution deals with the so-called Anglo-American Oil Press, manufactured by Mr. Robert Whitaker, of Leeds, and Lambert's Patent "Albany" oil press plant built by the same manufacturer.—*Water*, Dec. 16th, pp. 505-6. (Ill.)

4. Pneumatic Engines and Devices.

Air Compressors.—*The "Boreas" Air Compressor.* The compressor referred to is constructed in the works of Messrs. Alley and MacLellan, Ltd., and sold by Messrs. Lacy-Hulbert & Co., Pneumatic Engineers, of 25, Victoria Street, Westminster. It is to be obtained for belt-driving as well as for direct steam-driving. An illustration of the steam-driven type accompanies the text. Two features distinguish the "Boreas" Compressor from other pneumatic machinery of this kind, one being the provision of an intercooler between the low and high pressure cylinders, and the other an automatic regulator, which renders it unnecessary to stop and re-start the machine when an adjustment of the air supply is required. This regulator, besides possessing other advantages, regulates the steam supply, when no air is being pumped, to the exact quantity required to keep the compressor going.—*Machinery Market*, Jan. 2nd, 1902, p. 31. (Ill.)

5. Electric Machinery.

Electrical Generators.—*A new Electrolytic Generator.* This is a concise account of a generator having a capacity of 3,000 ampères at an e.m.f. of from 4 to 8 volts, recently built by the Holtzer-Cabot Electric Company of Boston, for the Imperial Ore Reduction Co., of Boston, to be used for refining purposes at their copper mines at El Paso, Texas.—*Mines and Minerals*, Dec., 1901, p. 161. (Ill.)

6. Various Mechanical Devices.

Automatic Wedge Hole Picking.—*A new Quarry Machine.* The machine here described should secure its inventor a small fortune since, if it performs what its inventor claims for it, it will render quarry owners independent of a very numerous and high priced but independent class of workmen, *i.e.* the men who pick wedge holes. The Plymouth Wedge Hole Cutter, as it is called, is being placed upon the market by the Ingersoll-Sargeant Drill Co., U.S.A., and may be applied to any stone which will break with wedges, in which wedge holes or sheers can be cut by hand, and it will greatly widen markets for dimension stones by considerably reducing the cost of their production and thus contribute to the prosperity of owners and quarrymen alike.—*Mines and Minerals*, Nov. 1901, p. 172. (Ill.)

Conveyors.—*Coal Conveying Plant at Edinburgh (McDonald Road Electricity Works).* Under this heading is described a conveyer plant made to the designs of Messrs. Kennedy & Jenkin for Newington, and erected by the New Conveyor Co., of Smethwick. Every part of the plant is duplicated, so that in case of accident no delay is caused. The capacity of the plant may be realized when it is stated that the hopper receives coal for one, either, or both of the two elevators at the rate of 30 tons per hour each.—*Electrician*, Dec. 13th, 1901, pp. 291-2. (Ill.)

Cost of Power Plant.—*The Cost for Small Plants.* By W. H. Wakeman. The author enters into an analysis of the conditions in which steam, gas, and electric motors are the most economical. He, naturally, repudiates the idea that it is possible to state the actual cost of power on the basis of a general outline of the conditions prevailing, as local factors form an ever-shifting element in the calculation. Roughly speaking, however, as he says, it is sufficiently correct to assume that, under good conditions, five pounds of coal will supply one horse-power for one hour in a steam-engine, and that one pint of gasoline, which is the equivalent of 17 cub. ft. of a fair quality of illuminating gas, will do the same in a gas-engine. If, besides these data, the price of coal and gasoline, and also the local price of electric current giving one horse-power per hour is known, it will not be difficult to decide which source of power is the most economical.—*Modern Machinery*, Dec., 1901, pp. 202, 203.

Electric Cranes.—*An Electric Travelling Crane.* The crane described is capable of dealing with a load of 20 tons, and was designed and constructed by Messrs. George Russell & Co., of Alpha Works, Motherwell, near Glasgow, and erected by them on the wharf at the works of the North-Eastern Marine Engineering Co., Ltd., Wallsend-on-Tyne, where it is used for placing the light parts of machinery on board new vessels or vessel under repair.—*Machinery Market*, Jan. 3rd, 1902, p. 35. (Ill.)

Belt Transmission.—*Belts and Modern Machinery* The author of this contribution tries to impress upon his readers that the times have changed, and that while during the period of slow-speed machines not much skill was needed in uniting belting, nowadays, when high-speed engines hold the field, staunch and compact gear is required; and thus also must be pulleys and belts, while the bulk of his remarks is devoted to the description of the most suitable and enduring form of unions.—*Modern Machinery*, Dec., 1901, pp. 185-7. (Ill.)

Gearing.—*The "Buffoline" Noiseless Gearing.* The gearing referred to is manufactured by the Buffoline Noiseless Gear Co., of Chapel St., Levenshulme, Manchester. The text is accompanied by the illustration of a pinion made by this firm, 2 ft. 6 in. diameter, 5 in. in width, having 47 teeth and a 2-in. circular pitch. It will trasmit 120 b.h.p. Besides doing this work noiselessly these pinions require no lubrication, are said to be lighter and stronger than cast iron and, of course, run without friction.—*Machinery Market*, Jan. 2nd, 1901, p. 35. (Ill.)

Indicators.—*Wind-Direction Indicator, based on the Three-Field System.* The above is the heading of a contribution containing the description of an electrical device for the automatical transmission of position of a weather vane showing the direction of the wind at a given locality to persons placed at a distance from it. This device is based upon the use of the three-field indicator system, invented by Professor Dr. L. Weber, of Kiel, whose patents were purchased by the "Allgemeine Electricitätsgesellschaft, Berlin." By means of this device the sending and receiving stations are in uninterrupted communication, and every change in the position of the vane at the sending station is instantly indicated on the scale of the receiving station, which, of course, is of considerable value for the study of meteorological problems.—*Electro Techniker*, Dec. 31st, 1901 pp. 372-5. (Ill.)

Pumps.—*Air Lift Pumps.* Description of a performance of an air-lift pump of the American Well Works (Chapman's Patent). A bore-hole made some nine years ago, to a depth of 450 ft. and 12 ins. in diameter, had been abandoned owing to the supply of water found being only about 1,000 gallons per hour. The owners of that well, recently hearing of the Chapman air-lift pumps, applied to the British American Well Works, 145 Queen Victoria Street, asking for an estimate for installing an air-lift pump, and demanding a guaranteed output of 5,000 gallons per hour. The estimate, which was for a plant equal to 15,000 gallons, was sent, and the guarantee given that failing the output of 5,000 gallons, no pay

would be demanded, and the plant taken out free of cost. Two days after installation an output of 15,000 gallons was obtained.—*Water*, Oct. 15th, pp. 416-7. (Ill.)

Safety Devices.—*Safety Device for Engines and Condensers.* Description of an ingenious device intended to keep the engine cylinder completely free from water in case the engine should act as a pump and the condenser is at a standstill. The principle underlying the invention can be applied for central condensing purposes, or for an air-pump used in connection with any number of engines.—*Scientific American*, Dec. 21st, p. 409. (Ill.)

Wagon Brake.—*Either-side Railway Wagon Brake.* In the Railway Employment (Prevention of Accidents) Act, 1900, a rule was made that "within five years from coming into operation of these rules, brake levers shall be fitted and subsequently maintained in good order on both sides of the wagons, and shall be so placed that the brakes can be conveniently operated upon from either of such sides," etc. This rule has naturally stimulated inventors to design devices satisfying this rule, and to secure what, no doubt, will turn out to be a very substantial reward. One such device has been designed by Mr. E. J. Hill, of 11, Victoria Street, Westminster, and is described under the above heading.—*Engineer*, Oct. 11th, 1901, p. 387. (Ill.)

7. Machine Works and Foundries.

BUILDING AND CONSTRUCTION.

1. Construction and Design.

Building Construction.—*Concrete Passenger Station for the Northern Pacific Railway, at Bismarck, N.D., U.S.A.* Although within the last few years there have been a few cases in which concrete was used for the construction of the walls and main supports of a building, such as a storehouse, an elevator, a private residence, etc. The railway station described under the above heading, the walls of which are entirely of concrete, appears to be the first of its kind. The style is very pleasing and appropriate, and the architect appears to have been inspired by a look at the remaining portions of the old "Mission" stations on the Pacific Coast, which offer many picturesque suggestions. As regards the material it may be said that its good qualities are becoming more and more appreciated, and it is not at all unlikely that the prediction may be fulfilled very soon, which Mr. Edison is said to have made some time ago, namely, that the railway companies ere long will keep forms for stations in stock, and when needed will have them transported to the place where they are wanted, and have the cement poured into them, and have it set like a plaster cast, after which there would remain nothing but to have the furniture brought in and the carpets tacked.—*Railway and Engineering Review*, Dec. 21st, 1901, pp. 808, 809. (Ill.)

Steel Frames in Buildings.—*A Steel-Frame Church.* This contribution contains a description of the structural details of St. Veronica's Roman Catholic Church at the corner of 133 Street and Alexander Avenue, New York, a stone and brick building with steel columns, framework, and roof, and representing a successful adaptation of steel construction to ecclesiastical requirements. The total weight of the steel consumed is stated to have been 376 tons.—*Engineering Record*, Dec. 14th, 1901, pp. 572-4. (Ill.)

2. Heating and Ventilation.

Bank Premises.—*Ventilating and Heating the Chicago National Bank.* The system employed is a combination of the plenum and exhaust system of distributing heated air in the basement and first storey, and by direct radiation in the other parts of the building. The article describing this system mentions many interesting details, among them are elaborate devices for cleansing the smoke-laden air brought into the building. Both steam and electric power are obtained from sources outside the building.—*Engineering Record*, Nov. 23rd, 1901, pp. 502-4. (Ill.)

Mixed Plant.—*Power Ventilation and Heating in the Colonial Building, Boston.* The building referred to is a ten-storey structure, which for the larger part is used as an office building, but includes in its lower four stories and basement a theatre seating 1,662 people. For the general mechanical purposes of the whole building there is in the sub-basement and a portion of the basement a steam plant of about 600 h.p. in water-tube boilers, two combined units of electric generators and steam-engines, a hydraulic elevator equipment—plunger type, and a water supply and sprinkled fire protection system. The description of the details of these various devices and their working occupies the bulk of the article.—*Engineering Record*, Nov. 30th, 1901, pp. 515-28. (Ill.)

Ventilating of Office Rooms.—*Ventilation of an Office Building.* One of the few office buildings, says the author in the article, in which means have been taken to effect positive ventilation for the many rooms is being completed in Hartford, Conn. for the Connecticut Mutual Life Insurance Company. Every office in general is warmed by direct-indirect radiators, and ventilation is obtained by the supply of fresh air thus admitted, with the additional provision of paths of escape through the ducts under the indirecting action of exhaust fans. The details of the installation are fully described and plans and sectional drawings assist the reader in perusing the text.—*Engineering Record*, Dec. 21st, 1901, pp. 597-600. (Ill.)

3. Lighting of Buildings.

Interior Lighting.—*The Lighting of Schools.* The Home Secretary of Bavaria recently appointed Dr. R. Seggel and Professor Eversbusch, two medical experts, to report to him as to modes of lighting, with special reference to schools. The result is published under the heading given above. The choice lies between various modes of incandescent light and electric light; ordinary gas light and oil lamps are not even mentioned.—*Gas World*, Jan. 4th, 1902, p. 25.

4. Water Supply of Buildings.

5. Sanitation.

6. Building Material.

7. Miscellaneous.

PUBLIC WORKS.

1. Building of Roads, Bridges, Viaducts, Tunnels, etc.

Bridge Building.—*The Inter-Provincial Bridge at Ottawa.* This heading refers to an article containing a detailed description of the structural peculiarities of a bridge across the Ottawa River at Nepean Point, having a length of about 2,287 ft., and connecting the cities of Ottawa, Ontario, and Hull, Quebec, in Canada. At the north it has a plate-girder approach and two pin-connected end spans, and at the south end two short plate-girder spans connecting it with the steep rocky hill, above and beyond which is the city of Ottawa. The remainder consists of a pin-connected through-truss cantilever 1,053½ ft. long between centres of archways, and 555½ ft. long between centres of main piers.—*Engineering Record*, Dec. 7th, 1902, pp. 538-42; and Dec. 14th, 1902, pp. 563-5. (Ill.)

Oil on Roads.—*Oil for Clay Roads.* The use of oil on dirt, gravel, and macadam is comparatively old, but the application of petroleum on what is called a "buckshot" road, near Charlesdale, Miss., U.S., is a novelty, as "buckshot," a tough black clay, is about the worst road material imaginable. The experiment was carried out under the direction of Major T. G. Dabney, Chief Engineer of the Yayoo Leven District, on 1,500 ft. of roadway, of which 400 ft. had previously been covered with a layer of coarse lake sand one-quarter inch deep; another 400 ft. had been covered with fine sand to the same depth, and the remainder of 300 ft. had been left uncovered. Oil was sprinkled over a length of 1,100 ft., and the amount of oil used was 95 barrels of 42 galls. each. This amount, however, is believed to have been far in excess of what would be required. The climatic conditions were very unfavourable, and the test, therefore, will

not be considered conclusive. Still, the result will be awaited with great interest.—*Engineering Record*, Nov. 30th, 1901, p. 519.

—— *The Value of Oiled Roads.* By W. C. Ambrose. The author draws attention to the fact that in the great valleys of California, where there are no summer rains, before the discovery of oil in the State there seemed to be no remedy for mending the roads than strawing them or sprinkling them with water. Strawing them, however, costs about 30 dols. a mile, is of very temporary value, only, and in many cases is not available at all. Sprinkling of water is very ineffective and, moreover, very expensive. A supervisor of Kern County, California, in a paper read before the San Joaquin Valley Association of Stockton, related that during the dry season he spent 35 dols. a mile per month in sprinkling his water, and yet there had not been a single day on which he could have said that the road was good. In other counties the farmers had still worse experiences. The discovery of oil in California, therefore, was a real godsend to them. The Kern County oil used for sprinkling has a gravity of 14 to 15 degs. Baume, and contains a little less than 60 per cent. of asphalt, which is non-volatile. The remainder, consisting of benzine, gasoline, naphtha, etc., is volatile, and in road-making serves to dissolve the asphalt, so that the sand or soil becomes saturated with it. The cost of sprinkling with oil amounts to a total of 300 dols. to 350 dols. a mile in three years, of which, say one-half the first year and one-fourth in each of the following years, would have to be expended to make a good road. The economy, therefore, is obvious, and the result is said to be highly satisfactory.

Tunnel Work.—*Moving a Long Tunnel Transversely.* A portion of Sect. 13 of the New York Rapid Transit Railway, between 136 Street and 138 Street, was completed last year as a two-track subway, with beam and concrete construction. It was afterwards decided to enlarge it to accommodate three tracks, and it was estimated to be cheaper to modify the existing structure than to tear it out and entirely rebuild, as was at first contemplated. The article bearing the above title fully describes the work undertaken with this object, involving the removing transversely the long brick retaining walls of the south incline approach, and moving the steel and concrete roof and side walls of the finished subway section, nearly 300 ft. long, 5½ ft. transversely, both ways from the centre line.—*Engineering Record*, Dec. 21st, 1901, pp. 590, 591.

TRANSPORTING AND CONDUCTING.

1. Railways.

Electric Railways.—*The Davos Platz-Schatz-alp Bahn.* By C. Wetzel, engineer, at Davos. This is a description of an electric wire-rope railway, which connects Davos, the well-known health-resort in the Canton of Grisons, with the Schatz-alp, about 300 metres higher up, and was opened to traffic Dec. 25th, 1899. The prime source of power used is gas-engines, in which Dowson gas is used, and which are placed at a central station in the valley of Davos, furnishing a continuous current at a tension of 2 by 210 volts, which then is transformed into a current of 420 volts for use for winding up the wire rope. The gradient of the line, for a short stretch in the beginning, is 36 per cent., but throughout the remainder—*i.e.* the bulk of the line—it is 47·39 per cent., the total length of the track being only 718 metres. The article contains detailed references to the construction of the line, the stations, the power plant with the gas-motors, the electrical plant, the mechanical devices for the wire-rope traction, etc. — *Mittheilungen des Vereins für die Förderung des Local und Strassen Bahn Wesens*, Nov., 1901, pp. 552-64. (Ill.)

Novel Freight Houses.—*A Modern Freight House, Wisconsin Central Railway.* At the annual convention of the American Railway Engineering and Maintenance of Way Association last year, the suggestion of two-storey freight houses, for cities where room is scarce and real estate is expensive, was offered as one of the ways of solving the problem of handling the large quantities of freight overcrowding the warehouses. This suggestion has been recently carried out in a freight house constructed for the terminal l.c.l. business of the Wisconsin Central Railway, which is located on Southwater Street, near the lake front, in Chicago. The building, which is 306 ft. long and 77 ft. 3 ins. wide, is intended for a six-storey building, but so far only three stories have been built. The article published under the above heading gives a detailed and interesting description of this new type of freight house, and is excellently illustrated.—*Railway and Engineering Review*, Sept. 14th, 1901, pp. 602-6. (Ill.)

Special Trains.—*The Royal Trains of the Canadian Pacific.* Description of the luxurious train built in the shops of the Canadian-Pacific Railway at Montreal for the use of T.R.H. The Duke and Duchess of Cornwall and York. The train here described consists of the day coach, Cornwall, and the night coach, York, the compartment car, Canada, the sleeping cars, Australia, India and South Africa, and the dining car, Sandringham, together with cars for the baggage and the railroad employés, nine coaches in all.—*Railroad Gazette*, Sept. 20th, 1901, p. 649. (Ill.)

Uganda Railway.—*The Mechanical Rift on the Uganda Railway.* Under the above heading a short article is published dealing with the deep rift running nearly due north and south, and being bounded on the east by the Kikuyen escarpment, and on the west by the Mau escarpment. The difficulties on that section of the line, which descends to the floor of the rift and re-ascends again, are naturally great; and this fact becomes still more evident upon reading the above contribution.—*Engineering*, Sept. 27th, 1901, pp. 442, 443. (Ill.)

2. Canals, Rivers, and Harbours.

Isthmian Canal.—*The Report of the Isthmian Canal—II.* The article here referred to is the continuation of one on the same subject, but dealing with the general features merely. The present article deals with the purely engineering features. The author does not reproduce the text of the report, as this is printed as Senate Document 54, 57th Congress, first session, and can easily be obtained on application. He confines himself to comments on the salient features.—*Engineering Record*, Dec. 21st, 1901, p. 585.

Lighthouse Illumination.—*The Application of the Kitson Light to Lighthouses and other Places where an extremely Powerful Light is required.* By John R. Wigham, M.R.I.A. The author introduces his description by pointing out that the electric light had been found quite unsuitable for lighthouse purposes, that sea captains have complained that in clear weather it was misleading, and in foggy weather absolutely useless, and that the Trinity House officials seemed to have concurred in this view, so that the oil lamp has been restored its old place. He then proceeds to describe an illuminant invented by an American named Kitson. This is really a gas light, though made from cold petroleum, and possesses all the valuable properties for lighthouse illumination which Professor Tyndall and the Irish Light Commissioners attributed to gas light. In the Kitson system of lighting the petroleum is contained in a steel receiver, and kept under an atmospheric pressure of about 50 lbs. per sq. in., which is kept fairly constant, and forces it through a soft brass tube of very small bore to the position where the light is placed. Being heated at this point, it is converted into a combustible vapour or gas, and discharged through a needle-hole orifice. The author, some years ago, had experimented with an illuminant of this nature, which met with high commendation on the part of Sir Robert Ball, F.R.S. He has since, so he says, greatly perfected the method of using it, and thinks that it will prove highly satisfactory in the lighthouse service.—*Scientific Proceedings of the Royal Dublin Society*, Sept., 1901, pp. 471-5.

MUNICIPAL WORK.

1. Sewerage.

Sewage Disposal.—*Sewage Disposal at a Leper Asylum.* The article deals with a very interesting series of experiments carried out by Mr. C. C. James, Deputy Executive Engineer for Drainage of the Bombay Municipality, in connection with the disposal of sewage at the Matunga Leper Asylum, at Bombay.—*Engineer*, Oct. 11th, 1901, pp. 371, 372. (Ill.)

2. Water Supply.

Municipal Water Supply.—*The Electric Pumps of the Roman Municipality.* For some years the municipality of Rome wished to pump a certain quantity of water from the Aqua Vergine aqueduct to the new districts of the lower part of the city, but an economical and constant supply of power could not be found. Since the use is being made of a spring known as Aqua Paola, which has come into possession of the municipality by acquiring various private rights, and a supply of 3,485 galls. per min. is used for the districts in question. The mechanical plant was supplied by the Italian - Swiss Company for Mechanical Construction, of Bologna, who ordered the electric machinery from the Maschinen Fabrik Oerlikon, and the cables and wires from Messrs. V. Tedeschi & Co., Turin, retaining for itself the supply of turbines and pumps. The article here referred to gives a concise but clear description of the plant and its working.—*Water*, Dec. 16th, 1901, pp. 519-22. (Ill.)

3. Street Paving.

Wood Pavements.—*Wooden Pavements at Home and Abroad.* By Frederic Arnold Kummer, Jun. Mem. Am. Soc. of C.E. He points out that the first failures in the laying down of wood pavements were due to the bad material used and to the inefficient methods employed. From the time that proper methods have been employed full satisfaction was given both in the United States and in other countries. In London alone, there exist at present millions of yards of such pavements. Their chief advantage consists in slight wear, and the small charge for maintenance.—*Municipal Journal*, Dec., 1901, pp. 284-6.

4. Miscellaneous.

Drainage Systems.—*The House and Town Drainage Systems of the Twentieth Century.* By Isaac Shaw, C.E. The author, in October 3rd, 1878, first introduced to the notice of the British public the automatic hydro-pneumatic sectional system of town drainage bearing his name, by reading a paper describing it at the Stafford Congress of the Sanitary Institute of Great Britain, a system that has been very successful and has since undergone many improvements, stated that, though excellent in its way, it was in so far imperfect as it contained no provisions for the ventilation of the drains and sewers, other than those approved by the Local Government Board. This defect he has since been able to remove entirely, and the method employed by him is fully described in the paper of which the heading is given above.—*Journal of State Medicine*, Dec., 1901, pp. 773-88.

ELECTRICAL SUPPLY INDUSTRY.

1. Power Plant.

Power Plant.—*The Trucker River Power Plant.* The plant here described has created much interest in the United States, not perhaps so much on account of its intrinsic merits as because it is intended to supply the Cornstock lode, near Virginia City, Nevada, with power, the most famous of all mines in the United States, being the source from which the so-called "Bonanza Kings" derived their colossal fortune. The mine had not been paying of recent years, as the power for mining, milling and pumping was mainly derived from steam generated with wood, costing from $3·50 to $15 per cord as fuel. This rendered the cost of power so high that milling had to be done on the Carson River, 15 miles distant, where water could be obtained at a reasonable price. An interesting feature of the new enterprise, which will greatly reduce expenditure, is a clause in the contract by which it is stipulated that current and power shall be measured by recording instruments at the sub-station, and that the number of horse-power furnished shall be determined by the maximum demand readings of such instruments.—*Engineering Record*, Dec. 14th, 1901, pp. 562, 563. (Ill.)

2. Transmission.

Gigantic Power Transmission Plant.—*Power Transmission on the Susquehanna.* By O. P. Waters. The above is the title of a short contribution on the subject mentioned, namely, the largest water-power development scheme ever established in Pennsylvania, and second in importance only to the Niagara power plant. This new scheme was started on June 17th, 1901, and is to be completed during the autumn of the present year. The basis of the enterprise, the seat of which is York Haven, on the Susquehanna River, 11 miles from York, Pa., is the utilisation of the entire body of the river at the Falls, which are situated a short distance beyond the power house. The latter has a length of 478 ft., a width of 51 ft. The equipment will consist of 40 turbine water-wheels of 600 h.p. each, operating 20 750-kilowatt generators, together with two turbines of 250 h.p. each, to drive machines for excitation. The contract for the generators has been awarded to the Stanley Electric Manufacturing Company, and for the turbines to Messrs. Robert Poole, Sons & Co., of Baltimore. The Company to which the enterprise is due has been capitalised at £3,000,000, and a bond issue has been made of £1,500,000. —*Electrical World and Engineer*, Nov. 30th, 1901, p. 891. (Ill.)

Transmission Problems.—*Long Distance Transmission into Chicago.* Short reference to contract closed for apparatus to supply the centrifugal pumps at Bridgeport in Chicago (which pump water from the Chicago river into the Illinois-Michigan Canal), with electric power generated at the power-house of the Economy Electric Light and Power Company of Joliet, 35 miles distant.—*Electrical World and Engineer*, Dec. 21st, 1901, p. 1027-8. (Ill.)

Wireless Transmission.—*Marconi Signals Across the Atlantic.* The article deals with M. Marconi's sensational achievement of signalling across the Atlantic from Poldan, in Cornwall, to Signal Hill, at St. John's, Newfoundland, giving a full description of the facts as stated by M. Marconi himself, who very modestly speaks of the event and carefully avoids exaggeration of the facts, which nevertheless, even if reduced to the utmost simplicity, must be accepted as forerunners of an entirely new epoch in telegraphy. The article also contains the story of the interference, on the part of the Anglo-American Telegraph Company, with the progress of the work.—*Electrical World and Engineer*, Dec. 21st, 1901, p. 1023-5. (Ill.)

Electric Railways.—*Electric High-Speed and Long-Distance Railways.* By O. Lasche. This is a digest of a lecture by the author, in which he draws attention to the ever-expanding industries in all civilised countries and the necessity of international exchange, which requires high speed in travelling. He then proceeds to show that such speed is most easily obtained by means of the electric current. The bulk of the lecture is devoted to an analysis of the electric method of locomotion, and to a demonstration of the advantages it possesses over other methods where speed is an essential factor, or where a cheap source of power is sufficiently near to permit its transmission by wire.—*Mittheilungen des Vereins für die Förderung des Local und Strassen Bahn Wesens*, Nov., 1901, pp. 547-5.

Street Railway Systems.—*The System of the Milford Holliston and Framingham Street Railway Co.* This article deals with a subject illustrating the very noteworthy street railway development at present going on around Milford, Mass., being without parallel not only in New England, but, perhaps, anywhere. About a year and a half ago the street-railway company above-named changed hands, and the new general manager soon effected a thorough transformation in extending the lines so that when completed the mileage will be more than doubled. The enterprise is in so far of general interest as the system is equipped in the most modern manner and represents the latest progress in the economic and efficient solution of the problem of electric traction.—*Street Railway Journal*, Dec. 19th, pp. 503-8. (Ill.)

3. Power Supply for Industrial Purposes.

4. Various Applications of Electricity.

MINING AND METALLURGY.

1. Mining and Mining Methods.

Pneumatic Concentrators.—*Pneumatic Concentration.* By E. B. Wilson. The author, after explaining what is meant by concentration, and describing the ordinary methods hitherto employed, gives a detailed account of the construction and use of the so-called Nooper concentrator, which has a capacity of from eight to twenty-two tons daily, and has been very popular in the United States for some time.—*Mines and Minerals*, Nov., 1901, p. 155, 156. (Ill.)

Hydraulic Mining.—*The Keystone Hydraulic Mine in Colorado.* Concise account of a hydraulic placer-mining enterprise inaugurated in San Miguel County, Colorado, some 3½ miles from Telluride, during the month of September, 1901. This enterprise has rarely been surpassed in extent and magnitude, says the writer, and in some details has never been equalled in the United States. The owners of the mine are the Keystone Hydraulic Mining Company, mostly consisting of New York capitalists who have invested the sum of 5,000,000 dollars, and a sufficient number of shares has been subscribed to raise ample working capital for the necessary equipment.—*Engineering and Mining Journal*, Oct. 5th, 1901, p. 724. (Ill.)

Mine Equipment.—*Giant Sand Wheel for the Calumet and Hecla Mining Company.* Description of the largest sand or refuse wheel in the world, in course of construction in the works of the Robert Poole & Son Company, of Baltimore, for one of the above-named Company's mines on Lake Superior. This wheel is designed for a capacity of carrying 550 sand buckets on the inner surface of its rim, and as the wheel will make 10 revolutions per minute, it will remove 5,500 buckets of refuse in that time, dump them into a trough at the top of it, where the contents will be carried off by sluice water. The greatest diameter will be 65 ft., and its weight, inclusive of bearings and supports, is given as 50 tons, while the axle, which was forged at Krupp's Works at Essen, is 27 ft. long, and has a diameter of 32 ins., with a 26-in. hole through the centre, weighing 42,000 lbs. The construction of so immense a wheel was, of course, a task of considerable difficulty, the casting had to be done in twenty segments, while for the cutting of the teeth on the outward rim a special milling machine had to be constructed. —*Scientific American*, Dec. 21st, 1901, p. 411. (Ill.)

Mining Methods.—*Some Methods of Timbering and Working Wide Lodes in New South Wales.* By J. R. Godfrey. Abstract of a paper by the author, read before the Australian Institute of Mining Engineers, and describing the operations in the Great Cobar Copper Mine, Cobar; the mines of the Cobar Gold Mines, Limited; Fort Bourke Cobar; the Prince of Wales Mine, Gundugai; and the Sibyl Mine, Gundugai.—*Engineering and Mining Journal*, Aug. 17th, 1901, pp. 199-201, and Aug. 31st, pp. 269, 270. (Ill.)

2. Quarrying.

3. Coal and Coke.

4. Copper.

Copper Mines.—*The Copper Mines of Ashio, Japan.* By Edwin G. Adams, Jr. The author, after an allusion to Japan's marvellous strides in the adoption of Western progress, draws attention to the fact that the abandoning of the old methods of mining has had the effect of greatly increasing the output of all mines - excepting iron—and this is particularly evident from the output of the copper mines, which increased from 4,810 metric tons in 1881 to 19,814 in 1894; and this increase at the same rate has, no doubt, continued. About one-third of the copper production is derived from the Ashio mines, which form the subject of the article published under the above heading. *Engineering Magazine*, October, 1901, pp. 69-78. (Ill.)

Copper Mines.—*The Verde Mining District, Arizona.* This contribution gives the history and gradual development of a copper-mining district which has already become famous by its wealth, and is considered to be of the very greatest promise for the future. The chief owners are the United Verde Copper Company, but the Iron King group (owned by Senator Clark), the Copper Chief group (largely owned in Springfield, Mass.), and others, are valuable properties and certain to increase in value in the near future.—*The Engineering and Mining Journal*, Aug. 10th, 1901, pp. 169-71. (Ill.)

Copper Mines.—*The Copper Mines of Santa Clara Province, Cuba.* By T. Wayland Vaughan, U.S. Geological Survey. The author, who publishes his interesting information with the sanction of Brigadier - General Leonard Wood, introduces his contribution with an outline of the essential topographic features and the general geology. He then gives a description of the localities where copper is found, and of which there are several in the province of Santa Clara, and finally draws his conclusions. There is copper ore—mostly sulphides (chalcopyrites)—of value, and it contains a considerable percentage of gold and silver; but all the data he has been able to collect do not suffice to make a correct statement regarding the real value of the mines. In order to do so, it would be necessary to pump water out of the old workings, so as to permit a study of them, and it is quite likely that additional prospect shafts must be sunk or tunnels must be driven ere an accurate opinion can be formed. Transportation facilities are not good at present, and a railway from Orenfuegos to Manicaragua would be of great service, and ought to pay for more than one reason. As regards the question of fuel, no deposits of value are known in Cuba, nor is it probable that they will be found. The nearest timber land to the mines is three miles off. Imported coke will probably have to be used in working the mines, and it will be necessary to determine whether charcoal or imported coke will be the more economical.—*Engineering and Mining Journal*, Dec. 21st, 1901, pp. 814-16. (Ill.)

Copper Ores.—*Some New Lights on Copper Metallurgy.* Extracts from a report to the State Department by the United States Consul at Marseilles, furnishing what he claims to be a "description" of the methods of treating copper ores in Spain. These methods, the Consul states, are limited to the treatment of low-grade ores, or ores not carrying more than 3 per cent. copper, in the province of Huelva. An amusing example of an attempt of a technical translation and a compilation of information gathered by a Government official who apparently lacks even elementary knowledge of the subject with which he is dealing, and whose linguistic attainments appear to be equally limited.—*Engineering and Mining Journal*, Oct. 5th, 1901, p. 422.

5. Gold and Silver.

Brazilian Gold Mines.—*The Morro Velho Gold Mine, Brazil.* Description of the equipment and working of the gold mine above-named, situated in the State of Minas Geraes, which is the best known and most important gold mine worked at present in Brazil, and is owned by the St. John del Rey Gold Mining Company, an organisation of British capitalists. The Company's latest report—*i.e.* that for the year ending February 28th, 1901—showed a production of 140,885 tons of ore, from which there was recovered 1,572,783 dollars in gold, or 11 dollars 16 cents per ton; the working costs amounting to 7 dollars 96 cents per ton.—*Engineering and Mining Journal*, 1901, pp. 485-489. (Ill.)

Gold-Mining.—*The Dahlonega Consolidated Gold-Mining Company's Plant.* Under this heading Professor Wilber Colwin describes an interesting gold-mining plant situated at Dahlonega, Georgia, which promises to render highly profitable deposits abundant in gold, but hitherto worked in a somewhat unsatisfactory manner.—*Engineering and Mining Journal*, Aug. 17th, 1901, p. 202. (Ill.)

Placer Mining.—*A Placer Mill, County California.* Description of a 40-ton capacity 10-stamp mill, recently constructed for the Washington Quartz Gold-Mining Company at Forest Hill, California. The entire machinery was purchased from the Union Iron Works of San Francisco.—*Engineering and Mining Journal*, Aug. 31st, 1901, p. 267. (Ill.)

6. Iron Ores and Mining.

7. Various Metals.

8. Miscellaneous.

Pumping Engines.—*Worthington Pumping Engine Co.'s Specialities.* The specialities here referred to are (1) a Worthington long-stroke, vertical-feed pump, specially designed for use in cases where a slow-running machine, making few reciprocations, is desirable; and (2) a marine feed-water heater, working on what may be termed the open principle, *i.e.* an arrangement by which the steam and water come into actual contact with each other without the intervention of tubes.—*Steamship*, Dec., 1901, pp. 226-8. (Ill.)

IRON AND STEEL INDUSTRIES.

Cast-Iron Pipes.—*English Practice in the Manufacture of Cast-Iron Pipes.* By Stephen H. Terry, M.Inst.C.E., M.Inst.M.E., etc. This is a paper read before the British Association of Waterworks Engineers, in which the author describes the modern practice of casting pipes as seen at the Woodside Works of Messrs. Cochrane & Co., of Dudley. He prefaces his description by remarking that whatever may be true or not true regarding the tendency of British manufacturers to remain behind the times in other directions, we are certainly in the front rank as regards pipe-casting. He then refers to the fame of Sussex as the birthplace of this industry at very early times, due no doubt to the fact that the ores and the material for the necessary fuel (charcoal) were close at hand in its vast forests. The chief portion of the paper, however, is devoted to the proof of the truth of the author's opinion that thick pipes are preferable to thin pipes, and to an account of the methods practised as above said at the works of Messrs. Cochrane & Co.—*Water*, Dec. 16th, 1901, pp. 497-500. (Ill.)

Converter Steel.—*The Tropenas Converter Steel Process.* Abstract of a paper read before the American Foundrymen's Association, in which the above-named process is described, which consists of a special converter serving for the conversion of iron, melted beforehand in a cupola into steel. This converter, like all others, is a sheet of steel shell lined with silica bricks or ganister and fitted with two hollow trunnions carried on pedestals, permitting the apparatus to be tilted as required. The interior is so arranged as to give the metallic bath a much greater depth than in all the other pneumatic processes. The blast enters the converter from the pressure blower through the trunnions, feeding the wind boxes and tuyères which direct the air over the metallic bath, pressure and volume of air being regulated by suitable valves. The characteristic features of the Tropenas process are, in short:—First, low-pressure blast, always above the surface of the metal; second, such a disposition of the tuyères in the horizontal plane as to make the jets of air enter into the converter above the bath and prevent them from setting up in it any gyratory or tumultuous motion; third, great depth, as above-stated, of the metallic bath, so as to avoid churning or stirring during the operation, the result being that the steel contains very little overloaded gas, and therefore flows quietly into the moulds, producing castings free from blowholes; fourth, the provision, above the "fining tuyères," and, independent of the latter, of auxiliary or combustion tuyères, so as to burn the combustible gases which escape from the bath, and which, in all other pneumatic processes, pass unconsumed up the chimney. In this way the temperature of the bath is considerably increased by radiation, and the pouring and other manipulations of the steel are rendered much easier.—*Iron and Coal Trades Review*, Oct. 20th, 1901, pp. 1039, 1040.

Gun Manufacture.—*The Largest Gun. One of the Recent Notable Products of the Machine Shops.* Summary of a report made by Colonel J. P. Farley, Ordnance Department, U.S.A., upon the 16-in. rifle recently completed for coast defence, reproduced from the *Engineering News*, which, although there have been constructed guns of slightly larger calibre, excels all others in energy and range. With smokeless powder it requires a charge of 576 lbs., and with a maximum powder pressure of between 37,000 lbs. and 38,000 lbs. to the square inch, it is intimated that this gun will throw a 2,370-lb. projectile, with a muzzle velocity of 2,300 ft. per second and a muzzle energy of 88,000 foot-tons.—*American Machinery*, September, 1901, pp. 7, 8. (Ill.)

Pig Casting.—*The Erskine-Ramsay Pig-Casting Machine.* Description of a machine designed by Mr. Erskine-Ramsay, chief engineer and assistant general manager of the Tennessee Coal and Iron and Railroad Company, Alabama, U.S.A., which, according to the inventor, requires but small power to operate; it is very efficient, as three-fourths of the moulds are always full, requires no roller-chain, links, sprocket wheels, bushes and rollers, by which circumstance the wearing surfaces are reduced, and delivers automatically the pig to the carrier, without "bleeding," and, finally, fills the moulds without spilling.—*Iron and Coal Trades Review*, Aug. 16th, 1901, p. 361. (Ill.)

New Iron Works.—*Iron Making on the Pacific Coast.* The article published under the above heading deals with an event of great importance to the Pacific Coast, namely, the resumption of iron-making at Irondale, some five miles south of Port Townsend, Washington. Here, 25 years ago, the first blast furnace on the Pacific slope was erected, only to be abandoned 12 years later. The Pacific Steel Company, however, after spending a quarter of a million dollars in carefully testing the chances of success, has repaired the old plant and equipped the works with entirely new up-to-date machinery, being convinced that, under the management of experienced men, both the iron mines in the district and the iron-works can be made to pay. The principal owners are all practical iron-makers of Pennsylvania. Considering the fact that heretofore practically every pound of iron and steel which the Pacific Coast consumed or sent over sea to foreign markets came from points east of the Mississippi river will suffice to show the far-reaching consequences if the experiment proves successful. For the present—*i.e.* until the neighbouring mines are sufficiently developed—the ore will be brought from Texada Island, British Columbia.—*Scientific American*, Dec. 21st, 1901, pp. 409, 410. (Ill.)

SHIPS AND SHIPBUILDING.

1. War Vessels.

Foreign Navies.—*Development of the United States Navy.* Under the above title, and in a cover, the front page of which is entirely taken up by an excellently coloured representation of the U.S. battleship *Georgia*, the paper mentioned below devotes a whole weekly issue to a series of articles dealing fully and interestingly with the various units constituting the modern navy of the United States. The text is accompanied by excellent illustrations.—*Scientific American*, Dec. 14th, 1901, pp. 373-91. (Ill.)

2. Passenger and Freight Vessels.

Atlantic Steamers.—*Express Steamship "La Savoie."* Description of the magnificent vessel bearing the above name, and recently completed at the shipyard of the Compagnie Générale Transatlantique, at Penhost, France. She has a length between perpendiculars of 557·6 ft., a displacement of 15,180 tons, and a registered tonnage of 11,680 tons. Her passenger accommodation is most luxurious, and her equipment and engines of the most efficient kind.—*Marine Engineering*, Dec., 1901, pp. 537-39. (Ill.)

Cargo Steamers.—*Single Deck Cargo Steamer.* This article contains a description of a new type of cargo boat designed by Sir Raylton Dixon & Co., of Middlesbrough. Its designers and builders claim for her that from all points of view she is an up-to-date earning vessel for quick loading and discharging, and she is well ballasted in light condition, the ballast being in such a position as to make her an easy sea-boat in heavy weather, and so assist in doing away with ruinous breakage of shafts in vessels running light.—*Engineer*, Jan. 3rd, 1902, p. 9. (Ill.)

3. Yachts and Pleasure Boats.

4. Machinery and Equipment of Vessels.

Gear for Launches.—*Gear for Electric-Driven Launches.* Description in detail of a gear employed by the Thames Valley Launch Company, of Weybridge, in which one lever switched on gives ahead or astern motion to the boat, at the same time varying the speed and stopping and steering when necessary.—*Marine Engineer*, Dec. 1st, 1901, pp. 347, 348. (Ill.)

5. Shipyards and Equipment.

Shipbuilding Works.—*The Works of the New York Shipbuilding Company.* Description of a shipbuilding works that possess special interest on account of the fact that, in contrast with other similar works founded many years ago and gradually changed to suit changed conditions, they are of so recent a date as to have come into existence, so to say, as a finished up-to-date product, embodying all the latest improvements, and may be considered to be the most important establishment of this kind in existence.—*Marine Engineering*, Dec. 1901, pp. 499-509. (Ill.)

Shipyards.—*The Schichau Works.* Description of the well-known works of E. Schichau at Elbing and Danzig, the former founded in 1837, the latter in 1891. These establishments comprise a total area of 155 acres, of which 17½ acres are covered with workshops, *i.e.* machine shops, iron, steel, and brass foundries, shipyards, locomotive and boiler works, etc., giving occupation to more than 6,000 workmen.—*Marine Engineer*, Dec., 1901, p. 362. (Ill.)

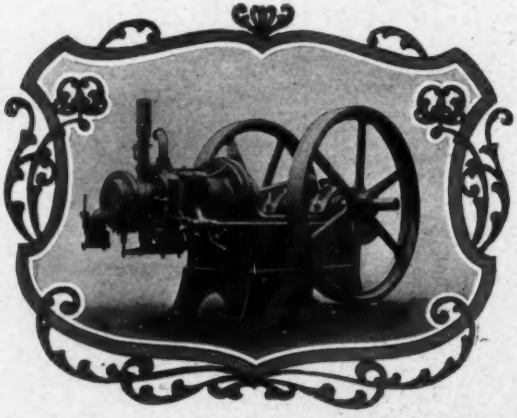
VARIOUS ENGINEERING MATTERS.

Electrical Therapeutics.—*The Electrical Treatment of Skin Disease.* The article contains a concise description of a number of ingenious appliances manufactured by Messrs. Marshall & Wood, under the direction of Dr. Sequeira, of the London Hospital, who has been very successful in the application of intensely actinic light to the cure of lupus and other skin diseases.—*Electrician*, Dec. 19th, 1901, pp. 294, 295.

Electrolytic Products.—*The Electrolytic Production of Chlorates.* The author, after pointing out that the electrolytic production of chlorate of potash had been inaugurated at Niagara Falls in 1893, states that the cell originally used was that patented by Franchat and Gibbs. The disadvantages, however, attending the use of copper oxide as anode material were so great that it had to be abandoned, or rather had to be considerably modified. In its present form, which is fully described by Mr. Kershaw, it is protected by the British patent. The chief feature of this remodelled cell is that it possesses copper-wire cathodes instead of flat cathodes of platinum or other metal, as is usually the case. The power used in the factory of the National Electrolytic Co. at Niagara is obtained from the Niagara Falls Hydraulic Power Co., and is transmitted to the Chlorate Factory by an aluminium conductor. The original supply consisted of a 5,000-amp. continuous current at 175 volts pressure, but has, it appears, since been doubled.—*Electrician*, Dec. 13th, 1901, pp. 304, 305. (Ill.)

Scottish Industries.—*Glasgow Engineering Congress and International Exhibition.* Under the headings (1) The Rise and Progress of Glasgow Industries, (2) The Industrial Works of Glasgow and Works visited, (3) Papers read at the Conference, the enterprising trades journal mentioned below publishes a "Special Engineering Congress Number," containing 113 pages of interesting and instructive reading matter, accompanied by numerous illustrations and diagrams, the whole constituting a memorial issue of far more than ephemeral value.—*Iron and Coal Trades' Review*, Sept. 6th, 1901, pp. 553-666. (Ill.)

Heating Devices.—*Indirect Steam Heating in a Residence.* The article describes the installation of an indirect heating plant in place of a furnace plant that had been in use for several years. The plant makes use of the difference in pressure between cold and warm air to maintain a circulation in the dual system.—*Engineering Record*, Dec. 14th, 1901, pp. 575, 576. (Ill.)



REVIEWS.

Specifications for Steel Bridges (taken from "De Pontibus").—By J. A. L. Waddell, C.E., B.A.Sc., First Edition. First Thousand. New York: John Wiley & Sons. London: Chapman & Hall, Limited. 1901.

This volume consists essentially of specifications reprinted from a larger work, produced two or three years ago under the somewhat fantastic title, "De Pontibus." In the preface to the present book, the author takes the public into his confidence by explaining that whilst considerable demand exists for his specifications, "De Pontibus" is too expensive a book for the general public to use for specifications alone, and he hopes the more recent publication will serve the required purpose at one-third the cost of the former treatise. We observe that some changes have been introduced with the view of bringing the specifications up to date. Thus, additional live loads have been included to provide diagrams for railway engines of the weighty types that are now employed both in America and in this country. The second modification provides for an increase in headroom for railway bridges, so that a tall man may safely stand with his hands over his head on a coach fifteen feet high. We are assured that such cars are in actual use, but it is not explained why anyone should adopt so picturesque an attitude on the top of a moving railway train. Evidently the practice must possess some fascination on the other side of the Atlantic, for we learn that facilities are afforded for its adoption on the lines of several railway companies. A third change is the recommendation that rollers should be enclosed in boxes made dust-tight and filled with oil that will not congeal at any possible temperature. This new detail is stated to be "now used in the author's practice"—information which seems to be a little irrelevant, although the device itself is in every way worthy of commendation. Alterations have further been made in several formulas for man-power apparatus in rotating draw-spans, with the object of reducing excess of weight required under the old rules. Some of the requirements in "De Pontibus" as to the percentages of elongation for steel have now been reduced after consultation with the representative of the largest steel-works in America, and some small changes are noticeable with regard to tests of eye-bars and rivets.

Four chapters are devoted to specifications written in general terms. The first chapter contains specifications governing the design of steel railroad bridges and viaducts, and the superstructure of elevated railways. This section concludes with details of design for rolled I-beam spans, plate-girder spans, open-webbed riveted girder spans, pin-connected spans, trestles and elevated railroads. Similar treatment is accorded in the second chapter to railroad draw-spans; in the third to steel highway bridges and viaducts; and in the fourth to highway draw-spans. The specifications are useful up to certain limits, and if due judgment is exercised they may be applied to girders and trusses of most ordinary forms and dimensions. Unfortunately, the volume is entirely devoid of illustrations, an omission which seriously detracts from its usefulness. Readers would certainly like to see diagrams of the different types of bridges described, so that essential points of difference might be more readily appreciated than is now possible. A chapter is devoted to general specifications governing the manufacture, shipment, and erection of steel bridges, and another to the compromise standard system of live load for railway bridges, a method advocated by the author, and very generally approved by engineers both in America and Great Britain. It may well be doubted whether bridge engineers will become purchasers of the work to any great extent, but it may be of service to students, if read in conjunction with some standard treatise on the subject.

Motor Vehicles and Motors, their construction and working, by Steam, Oil and Electricity.—By W. Worby Beaumont, M.I.C.E., M.I.M.E., and M.I.E.E. Price Two Guineas nett.

This veritable *magnum opus* has justly taken the position of the standard text-book of the rapidly increasing automobile industry, and its allied trades. It comprises over 600 quarto pages, and is full of diagrams and illustrations of the different apparatus that are, or have been used in automobilism, yet he would be a captious critic who would say that there is a page too much in it. In fact, the author remarks at the close he has still left out some matter that he would have liked to insert, and that many readers will no doubt look for, but as he must go to press sometime, and he had already promised the book for two years, he could no longer keep it back, and the other matter has to wait a later opportunity.

The author of the book comes to his task singularly well-qualified for the work, and he has produced a book in consequence that will hold its own among practical engineering text-books for many a long day. He also illustrates in a marked manner the best points of the modern engineer. He writes as a thoroughly practical man, as one who has a practical acquaintance with the apparatus he writes about, and who has also a thoroughly sound knowledge of the principles of the science upon which the art he writes on is based.

As the author states in his preface, his desire has been to provide inventors, and those who are working at the problems involved in the development of practical automobilism, with a full record of what has been done by those who have gone before, with, as far as possible, the reasons for their failure where they have been unsuccessful, and also to provide all who are interested in the subject with a concise statement of the main principles governing the art that he and they are interested in, and he has done both well. His historical *résumé*, which is given in the Introduction and in Chapters I. and II., are well worth the perusal of everyone who is interested in the subject. As Mr. Beaumont points out, it does not follow because an apparatus that was invented a good many years ago did not come on to the market,

or did not live when it was placed on the market, that it was therefore wrong or really unsuccessful in the engineering sense of the term. Conditions have changed enormously since the late twenties and early thirties of the last century, when a determined attempt was made to introduce a successful motor car.

It is interesting to note that a considerable amount of success was achieved, in spite of all the difficulties, and also that in some of the successful motors very high steam pressures were employed—as high as 200 lbs. per sq. in. Evidently the inventors of motor cars of those days were ahead of their fellows, and reaped the usual reward. The author makes one very striking remark in reviewing the efforts of seventy years ago. He says that those inventors who provided plenty of power were successful, while those who did not do so were out of the running altogether. Perhaps there is no sounder or more useful sentence in a book which is full of useful advice not only to those who are engaged in the motor-car industry, but also to engineers generally. Probably nothing has wrecked the hopes of inventors more than the sanguine feeling that is so common that little power is required.

In the book under notice the author has done more than is usual—or, at any rate, was usual till very recently—to warn the inventor of the pitfalls into which he may wander if he is not careful. If the inventor and the designer will carefully study the tables and the formulæ that Mr. Beaumont gives him, using them intelligently, not blindly, he will save himself a good deal of time and money. In Chapters III., IV., V. and VI. Mr. Beaumont has discussed very fully the power and frictional losses, the road resistances, the resistance due to gravity, and the air and wind resistances; and he gives tables showing the frictional losses under different conditions, the road resistances of different kinds of road materials, with different forms of tyres, the effect of broad and narrow tyres, etc., all of which will be of great use to designers, and also to those who have at any time to form a judgment as to the possible capabilities of a car.

In the latter portion of the book the author has discussed—very fully the important points of—Braking, in Chapter XXXIII.; of Vibration and Balance, in Chapter XXXIV.; Pivoted Steering Axles, in Chapter XXXV.; The Uses and Cost of Working, in Chapter XXXVI.; and Tyres, in Chapter XXXIX., in a practical and, at the same time, a thoroughly scientific way. The designer is given formulæ for calculating the power that his brakes must absorb, and the length over which his brake-handle, or his brake-wheel, must move; and he is shown how the formulæ are arrived at, so that where he has special conditions to deal with he can modify the formulæ to suit them.

In the chapter on vibration, balancing, etc., the author also gives some very useful hints to intending inventors. He points out that the vibration which is so noticeable when a petrol car is standing, say, in a street, is not due to want of balance of the engines that are employed in driving it, but to the fact that the motor itself only takes an explosion, perhaps once in twenty cycles, and that it then takes a full charge. Inventors, he points out, should turn their attention to providing means for maintaining the same number of explosions when standing as when running, the necessary lessening of the power used being arranged by the admission of a smaller quantity of the explosive mixture into the combustion chamber, and, as a possible eventual solution of the problem, mentions the cases where the admission of the gaseous mixture is throttled instead of the number of explosions being curtailed. As he points out, the more even running of the steam engine, and its freedom from vibration, are partly due to the ability of the steam engine to throttle its agent.

In the chapter on the costs some very interesting and instructive figures are given. Thus the comparative cost of several sizes of vehicles, when driven by horses and by motors, are discussed; and, in the case of the large steam lorries, the cost of conveying pianos, timber, etc., by motor cars employed in different manners, for the whole and for part of the journey, are compared with the cost when the railway company undertake the whole delivery. His estimate for two-seated vehicles, by horse, by oil motor, and by electric motor, is favourable to the oil motor, provided that it is used for 30 miles per day for 200 days in the year; while for 25 miles per day for 200 days in the year the electrical vehicle comes out slightly favourable as compared with the horse. For the large lorries carrying pianos the cost comes out in favour of the motor car, according to the author's figures. An interesting comparison in this connection is that given between the cost of a four-seated vehicle when fitted with solid rubber tyres and with pneumatic tyres. The cost with solid tyres is very much less than with pneumatic tyres, owing entirely to the cost of renewing the latter. In the same chapter the author points out that the greatest mileage has been obtained from solid tyres on vehicles of moderate weight, running at moderate speed. For high speeds the pneumatic tyres must be used, but the cost is heavy.

The remainder of the book consists of a detailed description of nearly every type of motor car that has ever been built—driven by steam, oil, petrol, electricity—from the period mentioned 70 years ago up to the date of going to press. The descriptions are very fully illustrated with drawings of the complete apparatus, and also with diagrams, very carefully prepared and very readable, of all the essential parts. The question of ignition is fully discussed, and all the methods of ignition, by tube and by electricity, are fully explained and fully illustrated with diagrams. Perhaps the only weak points in the book are in connection with theoretical dissertations, but this is of very little moment. The book is one that is full of very valuable information to everyone who is interested in the work of an autocar in any form whatever. It already forms the book of reference in many quarters, and it might well form the staple of the library of everyone who owns an autocar. Perusal of its pages would save many a guinea.